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WESTERN SPRUCE BUDWORM SUPPRESSION AND EVALUATION PROJECT USING CARBARYL

1977

Progress Report No. 1

Forest Insect and Disease Management
State and Private Forestry
Forest Service, USDA, Southwestern Region
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Albuquerque, New Mexico 87102

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by

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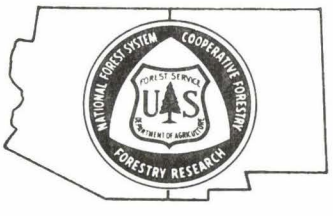

ACKNOWLEDGEMENTS

In conducting the application phase of this multi-year project, many Forest Service employees rendered valuable advise and assistance. They are too numerous to mention, but each has our sincere thanks. Credit is given to Bill Jack Rodgers, Los Alamos Scientific Laboratory, Department of Energy, for taking the photographs used in Figures 10 and 37.

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CONTENTS

	Page
ABSTRACT	1
I. INTRODUCTION	2
A. Control Strategy	2
B. Objectives	3
C. Project Area	3
II. PROJECT PLANNING AND OPERATIONS	9
A. Environmental Statements	9
B. Headquarters	9
C. Personnel	9
D. Financial Plan	10
E. Aerial Application	15
1. Type of Aircraft	15
a. Aerospatiale Lama Helicopter	15
(1) Identification Information	15
(2) Spray System	17
b. Hiller Helicopter (N62395)	17
(1) Identification Information	17
(2) Spray System	18
c. Hiller Helicopter (N65148)	18
(1) Identification Information	18
(2) Spray System	20

Page

2. Ground Handling Equipment 20

a. Transfer pump and meter 22

b. Mixing Tanker 22

c. Recirculating Pump 22

d. Aircraft Transfer Pump and Meter 23

3. Spray Formulation 23

4. Mixing Procedure 23

5. Calibration 25

6. Nozzle Arrangement 25

7. Log of Calibration and Formulation Chief 28

8. Comments by Calibration and Characterization Chief 30

9. Spray Charcterization Trials 31

10. Spray Deposit Assessment 32

11. Airborne and Fallout Drift 42

12. Weather Forecasting and Meteorological Monitoring 50

13. Orientation of Spray Aircraft 59

III. ENTOMOLOGICAL PHASES 67

A. Objectives 67

1. Timing Insecticide Application 67

2. Immediate Project Effectiveness 67

3. Long-term Project Effectiveness 67

Page

B. Methods 67

1. Sampling Locations 67

2. Timing Insecticide Application 84

3. Evaluating Immediate Project Effectiveness 87

a. Sampling Design 87

b. Analysis of Larval Mortality 88

4. Evaluating Long-term Project Effectiveness 90

a. Sampling Design 90

(1) Sampling Bud-Mining Larvae 91

(2) Sampling Late-instar Larvae 91

(3) Egg Mass Sampling 91

b. Analysis of Population Reduction 91

(1) Assumptions 93

(2) Hypothesis to be tested 93

C. Results and Discussion 93

1. Timing Insecticide Application 93

2. Evaluating Immediate Project Effectiveness 95

3. Evaluating Long-term Project Effectiveness 98

a. Bud-Mining Larvae 98

b. Late-instar Larvae 98

c. Egg Masses 100

Page

IV. TREE DAMAGE APPRAISAL PHASES 103

A. Objectives 103

1. Evaluating Defoliation 103

a. Immediate 103

b. Long-term 103

2. Evaluating Tree Growth Loss 103

3. Evaluating Tree Mortality and Top-kill 103

a. Seedling and Sapling 103

b. Sawtimber 103

B. Methods 103

1. Evaluating Defoliation 103

a. Immediate 103

b. Long-term 105

2. Evaluating Tree Growth Loss 106

3. Evaluating Tree Mortality and Top-kill 106

a. Seedling and Sapling Mortality 106

b. Sawtimber 106

C. Results 107

1. Evaluating Defoliation 107

a. Immediate 107

b. Long-term 109

2. Evaluating Tree Growth Loss 109

Page

3. Evaluating Tree Mortality and Top-kill 109

a. Seedlings and Saplings 109

b. Sawtimber 111

V. MONITORING 115

A. Objectives 115

B. Methods 115

1. Birds 115

2. Aquatic Organisms 115

3. Small Mammals 118

4. Reptiles 118

5. Non-Target Insects 118

6. Insect Parasites of the Western Spruce Budworm 119

C. Results 120

1. Birds 120

2. Aquatic Organisms 120

a. San Pablo Creek 120

b. Rito la Cuevo Creek 123

c. Trail Creek 127

3. Reptiles 130

4. Mammals 130

5. Non-Target Insects 130

a. Malaise Traps 130

Page

b. Sweep Netting 132

c. Blackfly Larval Mapping 132

d. Black-Light Trapping 132

6. Insect Parasites of the Western Spruce Budworm 132

VI. PLANS FOR F.Y. 1979 134

A. Equipment Rental 134

B. Equipment and Supply Purchases 134

C. Personnel 135

D. Administrative 135

E. Service 136

ABSTRACT

The application phase of the Western Spruce Budworm Suppression and Evaluation Project on the Santa Fe National Forest was successfully completed in 1977. Sevin®-4-oil was applied over 37,450 acres of forested land from June 10 to 19. The 1976-7 budworm generation was reduced by an average of 93.1 percent compared with a 44.5 percent reduction in the untreated check area. The adjusted budworm mortality, using Abbott's formula, was 87.5 percent.

The 1977-8 budworm generation will remain at a low level in the treatment area. The average egg mass density was 1.6 new egg masses per square meter (1.0 new egg masses per 1,000 square inches) in the treated area and 11.2 per square meter (7.2 per 1,000 square inches) in the untreated check area. The infestation in the untreated check area is expected to increase in size and defoliation intensity in 1978.

Even though an average of 84.1 percent of the budworm larvae were in the fifth and sixth instars and 0.3 percent were pupae at the time of treatment, defoliation in the treatment area was considerably less than in the untreated check area: treated area, 26.5 percent defoliation for Douglas-fir and 37.1 percent for white fir; untreated check area, 40.8 percent defoliation for Douglas-fir and 61.3 percent for white fir.

No significant adverse effects of treatment were found for birds, small mammals, reptiles, and non-target insects. An accidental spraying of San Pablo Creek caused a high reduction in drift of aquatic insects, this reduction should be temporary. Fish placed in the stream showed no effects from the treatment. The percent parasitism for the western spruce budworm was about the same in the treatment and untreated check areas.

In 1978, evaluation of effectiveness of the 1977 treatment for the budworm will continue. Tree damage assessment and environmental monitoring also will done.

I. INTRODUCTION

A. Control Strategy

Since the mid-1960's, after the phase out of DDT by the Forest Service, a major effort was made to evaluate alternative insecticides that could be used for suppression of western spruce budworm, Choristoneura occidentalis Free., outbreaks. Promising insecticides, identified through screening tests and field experiments, were pilot tested over relatively large forested areas to determine their effectiveness in suppressing a single generation of this budworm. Data collected during these pilot projects, along with other data, were used to obtain malathion and carbaryl registration. In terms of treatment efficacy, carbaryl (Sevin® 4-oil) has yielded the best and most consistent results; however, follow-up studies have not been done in treatment areas to determine if a single treatment could suppress budworm populations for more than 1 year.

Generally, two control strategies have been used in the West: the foliage protection strategy and the population reduction strategy. In some cases, a combination of these strategies has been used.

The objective of the foliage protection strategy is to save enough foliage to prevent serious tree deformities, top-kill, growth loss, reduced seed production, and tree mortality. Pesticide treatment is undertaken in areas where defoliation has occurred for many years, and one more additional year of defoliation will cause unacceptable tree damages. Advantages of this approach are that areas needing treatment can be more readily identified, initial suppression costs can be held to a minimum, and there is minimal risk of inaccurately predicting a budworm infestation trend in the next generation. Major drawbacks to this approach are that most of the growth loss and some of the other tree damages have already occurred, which reduces the economic advantage, and repeated treatment is often required because chemicals are only applied where unacceptable tree damages are expected to occur.

The objective of the population reduction strategy is to reduce the budworm population to such a low level that mating becomes less likely, parasites and predators become more significant in regulating the populations, and density-independent factors, such as weather, keep the budworm population below an economically damaging level. A major advantage of this strategy is that treatment can be conducted early in an infestation cycle to prevent tree damages. Disadvantages are that initial treatment costs can be higher and infestation trends and subsequent tree damages must be estimated for several years in advance, which is a high-risk decision.

Theoretically, the population reduction strategy offers the best long-term protection; however, no evaluations have been made to determine the prolonged treatment effects of any of the available pesticides on subsequent budworm generations. As Ciesla (1974) [1/] indicated, information needs to be collected on the minimum acreage requiring treatment to prevent re-infestation from the in-flight of egg-laying moths, thereby eliminating the need for repeated treatment. Of more immediate concern, however, is the need to determine the capacity of the resident budworm population, not killed by treatment, to increase again to damaging levels. This project was initiated to gain insight into the prolonged effects of treatment.

B. Objectives

Objectives of the project were to:

1. In 1977, suppress the budworm population on 37,450 acres (34,000 acres on the Santa Fe National Forest and 3,450 acres on the Jemez Pueblo Indian Reservation) to as low a level as possible. Criteria established to show success were reducing the budworm population by an average of 90 percent and obtaining an egg mass density of 1.5 new egg masses per square meter or about one egg mass per thousand square inches of foliage.

2. Evaluate prolonged effectiveness of suppressing the budworm population for 2 or more years after treatment by follow-up information-gathering on infestation trends and timber resource damages in:

a. The 37,450-acre treated area where a building infestation was suppressed in 1977.

b. A comparable untreated check area of 37,398 acres where the building infestation is allowed to progress naturally.

C. Project Area

Forest conditions in New Mexico, i.e., isolated stands of host trees infested by the budworm and an increasing infestation trend, were favorable for evaluating the lasting effects of chemical treatment. The entire infested host type could be treated, thereby enabling entomologists to evaluate the resurgence of budworms remaining after treatment. Elsewhere in the West, contiguous stands of host trees and the large size of budworm infestations limit the opportunity for total treatment, and budworm populations in stands surrounding the control blocks are available to re-infest treatment areas.

1/ Proceedings of a Symposium on the Spruce Budworm, Nov. 11-14, 1974, Alexandria, Virginia. USDA Misc. Publ. No. 1327, Sep. 1976. Pg. 55.

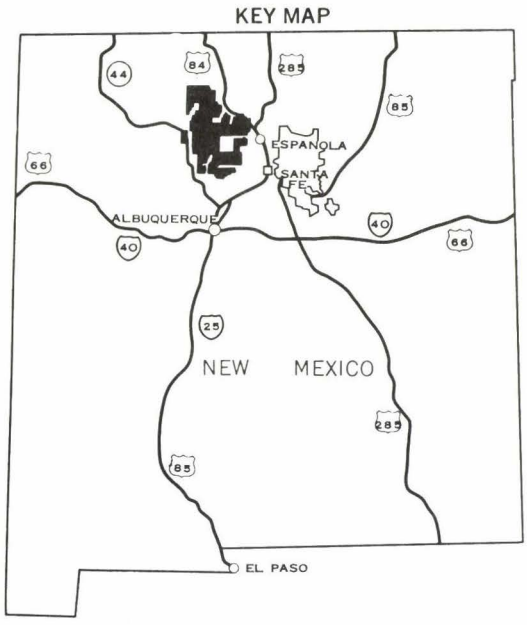
The project area is in the Jemez Mountains of north-central New Mexico in Sandoval, Rio Arriba, and Los Alamos Counties (Fig. 1). Chemical treatment was done on 37,450 acres of Federal and Indian lands in the Sierra Nacimiento and on associated mesas southeast of Cuba, New Mexico (Fig. 2). Comparable untreated check subunits of 37,398 acres are located to the east of the treatment area toward Los Alamos, New Mexico (Fig. 2 & 3).

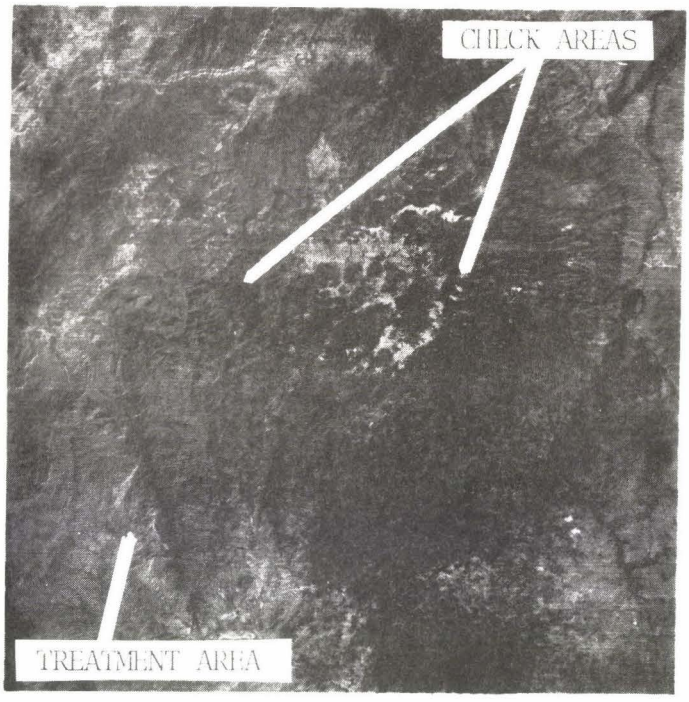
Landforms in the treatment area fall into two distinct types. The Sierra Nacimiento to the south is a deeply dissected mountain range with several prominent peaks (Big Peak - 9,379 feet; San Miguel Peak - 9,473 feet; Joaquin Peak - 9,097 feet). This range rises abruptly from a 7,000-foot plateau lying to the west. The mountains in general are moderately steep, with 15 to 40 percent slopes. Some drainages have locally greater slopes. By contrast, the terrain to the north consists of several prominent mesas (Big Mountain - 9,000-9,200 feet; Eureka - 9,000-9,600 feet). Although the mesa tops have slopes of 0 to 15 percent (Fig. 4), the mesa sides are moderately to extremely steep, with 30 to 80 percent slopes (Fig. 5).

Size (acres) of treatment and untreated subunits follows (Fig. 2 & 3):

Treatment Subunits		Acreage
1.	San Miguel	6,288
2.	Joaquin	5,755
3.	Smokey Bear	6,613
4.	Trail	6,388
5.	Blue Bird	6,928
6.	Red Top	5,478
	Subtotal	37,450

Untreated Check Subunits		Acreage
7.	Ojitos	6,326
8.	Lake Fork	4,123
9.	Cochiti	10,843
10.	Capulin	5,341
11.	American Spring	4,267
12.	Los Alamos	6,498
	Subtotal	37,398
	Grand Total	74,848





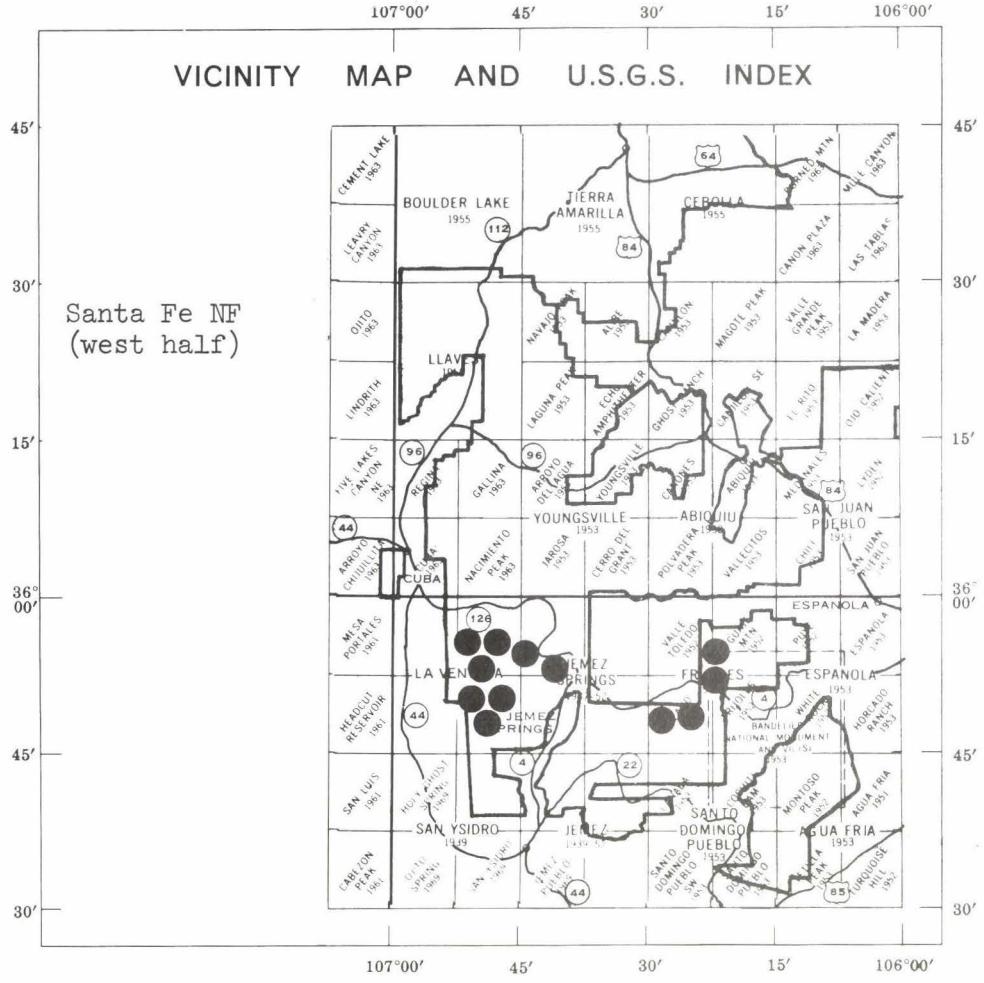


Figure 1. Spots on vicinity map of the west portion of the Santa Fe National Forest show general locations of treatment and untreated check subunits, 1977.

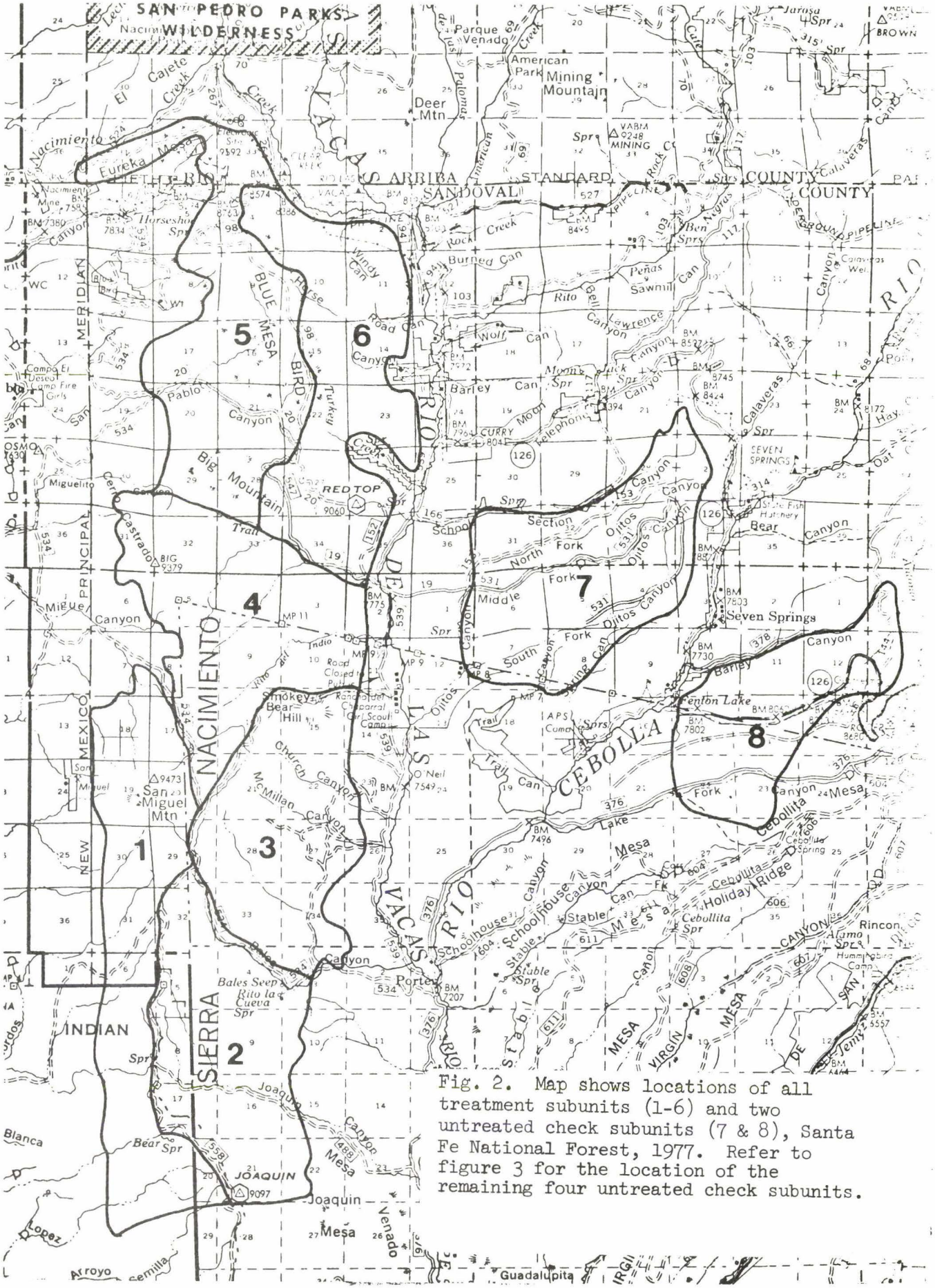


Fig. 2. Map shows locations of all treatment subunits (1-6) and two untreated check subunits (7 & 8), Santa Fe National Forest, 1977. Refer to figure 3 for the location of the remaining four untreated check subunits.

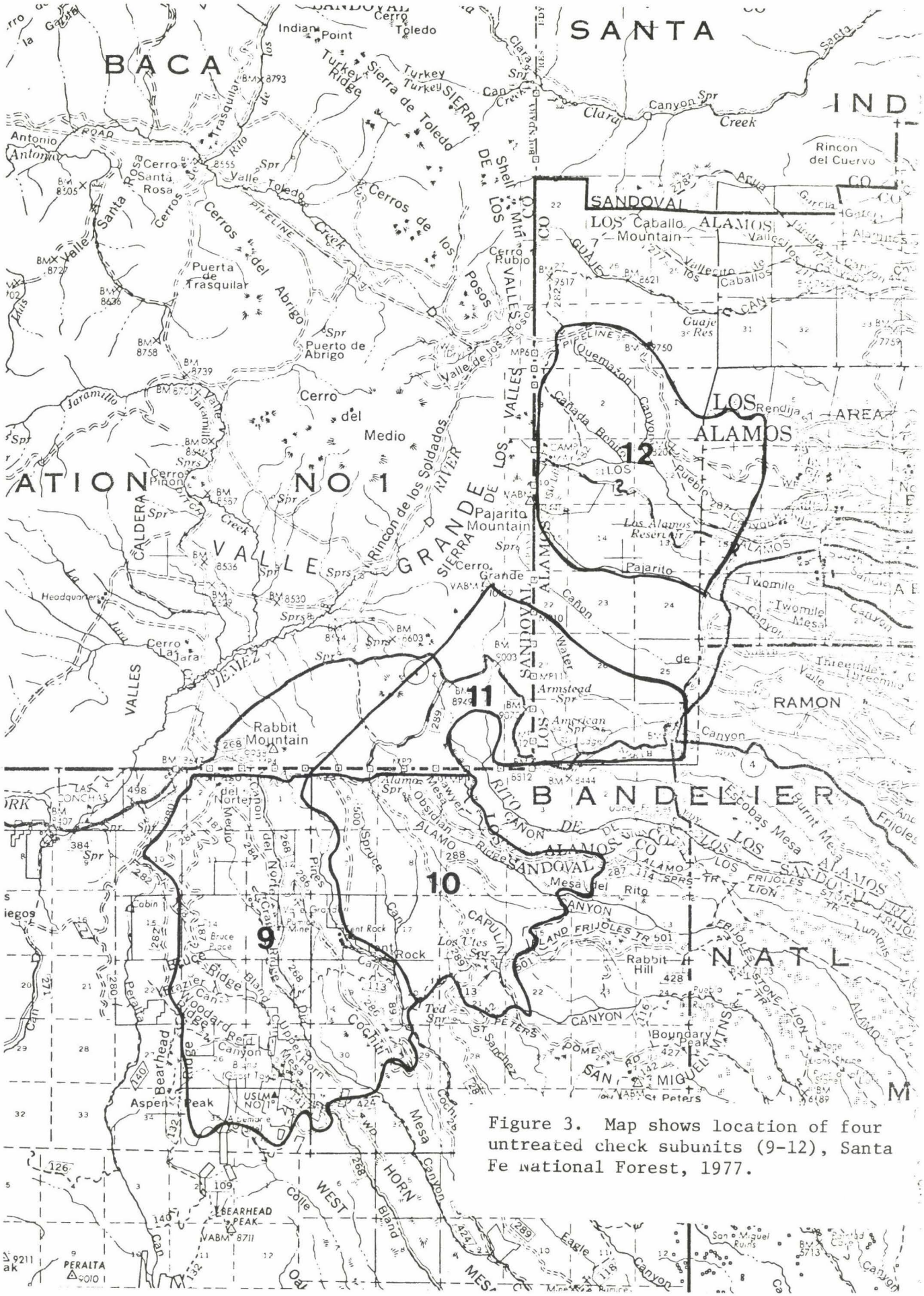


Figure 3. Map shows location of four untreated check subunits (9-12), Santa Fe National Forest, 1977.

Figure 4. Helicopter treating a mesa top, Santa Fe National Forest, 1977.

Figure 5. Helicopter treating a moderately steep slope, Santa Fe National Forest, 1977.

II. PROJECT PLANNING AND OPERATIONS

A. Environmental Statements

Since a registered chemical was proposed for use to suppress a budworm outbreak and the project has a major Federal action, Christobal B. Zamora, Supervisor, Santa Fe National Forest determined that an Environmental Impact Statement (P.L 91-190, National Environmental Policy Act of 1969) would be prepared by the Forest Service. A Draft Statement was prepared in the fall and winter of 1976-77 proposing suppression of the budworm outbreak using carbaryl. The alternative actions considered were: no control, silvicultural techniques, biological agents (parasites, predators, and microbial insecticides), other insecticides, and a smaller-scale pilot project. The Draft Statement was filed with the Council on Environmental Quality on January 31, 1977. A total of 22 responses to the proposed action was received during the 60-day review period.

The Final Environmental Statement was filed with the Council on Environmental Quality on May 6, 1977. Again, treatment of a 37,450-acre area with carbaryl was proposed. Plans were to begin spraying operation on June 10, 1977, which was after the required 30-day review period.

B. Headquarters

Headquarters for the pilot project was located in Los Alamos, New Mexico. This was the closest city with adequate motel space, restaurants, and other facilities needed for the project. Most of the untreated check subunits were close to the headquarters, but it took about 2 hours to drive to the most remote parts of the treatment area. Due to the long travel time from the headquarters to the treatment area, air operations personnel were stationed at Cuba, New Mexico, which was closer to the treatment area. The Cuba Ranger District administrative site was used as a base for the aerial operations. Project personnel realized that it would be more difficult to coordinate operations between the headquarters and the Cuba work site, but there were no other options. This arrangement did prove to be difficult, but all operations were satisfactorily completed.

C. Personnel

Personnel from the Forest Insect and Disease Management Staff Unit, State and Private Forestry, Albuquerque, New Mexico, in cooperation with the Santa Fe National Forest, administered the project. At the peak of project operations, a total of 35 individuals were working on the project. Also, there were many others working on aircraft inspections, contracting, satellite studies, or observing spray operations.

Personnel for the project were recruited from the Carson, Coronado, and Lincoln National Forests, and from Regional Office Staff Units in Region 3. In addition, valuable assistance was provided by the Methods Application Group (MAG), Davis, California, and the Missoula Equipment Development Center (MEDC), Missoula, Montana. Environmental monitoring was done by personnel from the U.S. Fish and Wildlife Service, University of New Mexico, and Museum of Northern Arizona.

Refer to Figures 6-9 for diagrams of the project organization.

D. Financial Plan

It was estimated that the spraying, insect sampling, tree damage sampling, and other project work during the first year would cost $337,200.00. If the total cost is compared with the 37,450-acre treatment area, the per acre cost was $9.00. The actual cost was $319,387.00 or $8.53 per acre.

An outline of the 1977 financial plan and actual costs follows:

		F.Y. 1977 Planned	F.Y. 1977 Actual
1.	Aircraft		
a.	Spray helicopters ($2.20/acre)	78,100	81,480
b.	Chase helicopters ($125.00/hour)	16,200	6,400
c.	Aircraft rentals	---	1,440
d.	Total	94,300	89,321
2.	Pesticide		
a.	Sevin®4-oil (bulk $8.25/gal.; drums, $8.80/gal.; tanker, $288.00/day)	85,165	83,965
b.	Oil carrier ($0.42/gal.)	6,600	4,200
c.	Automate red B dye ($492.00/30-gal. drum)	3,936	3,936
d.	Total	95,703	92,101

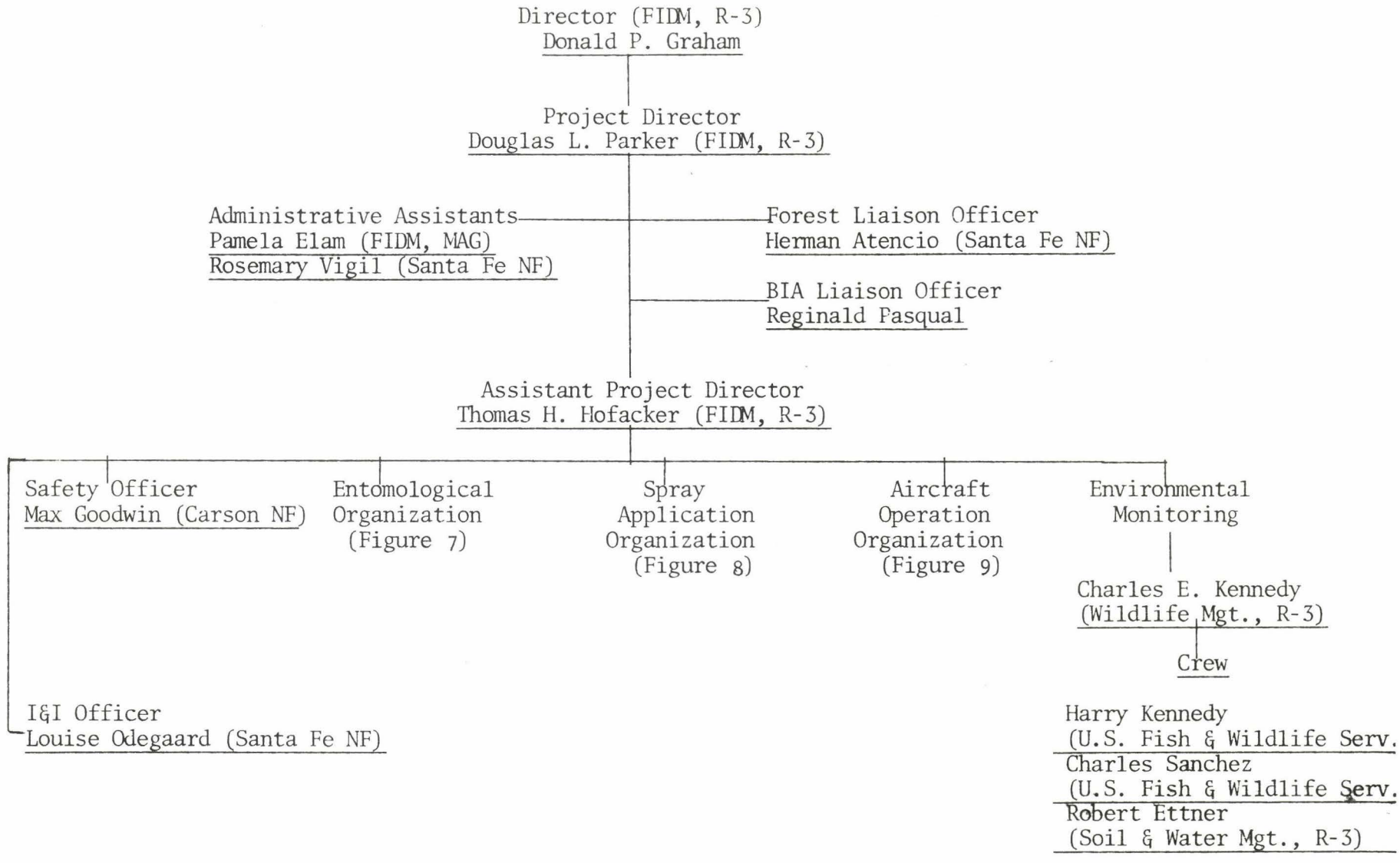


Figure 6.--Western spruce budworm suppression and evaluation project organization, Santa Fe National Forest, 1977.

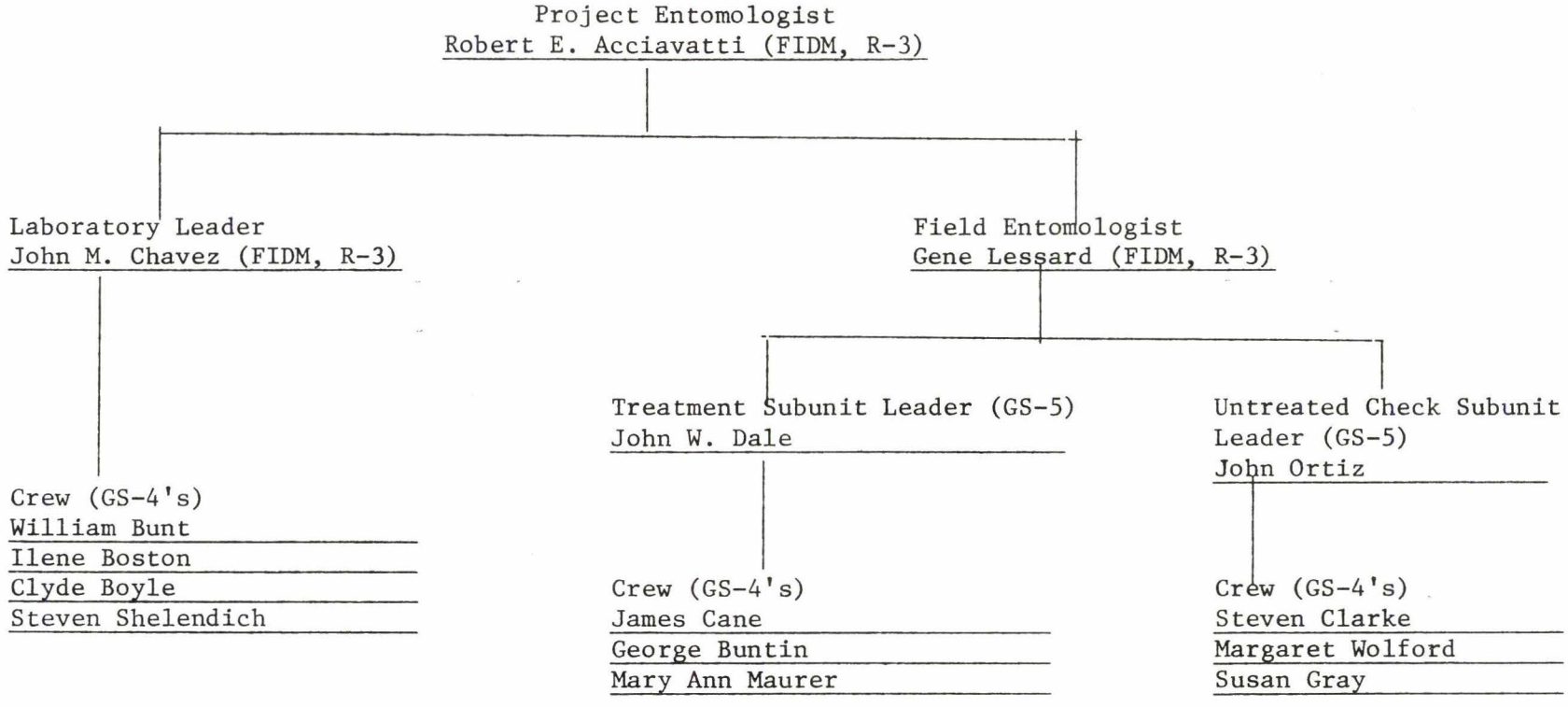


Figure 7.--Entomological organization for the western spruce budworm suppresssion and evaluation project, Santa Fe National Forest, 1977.

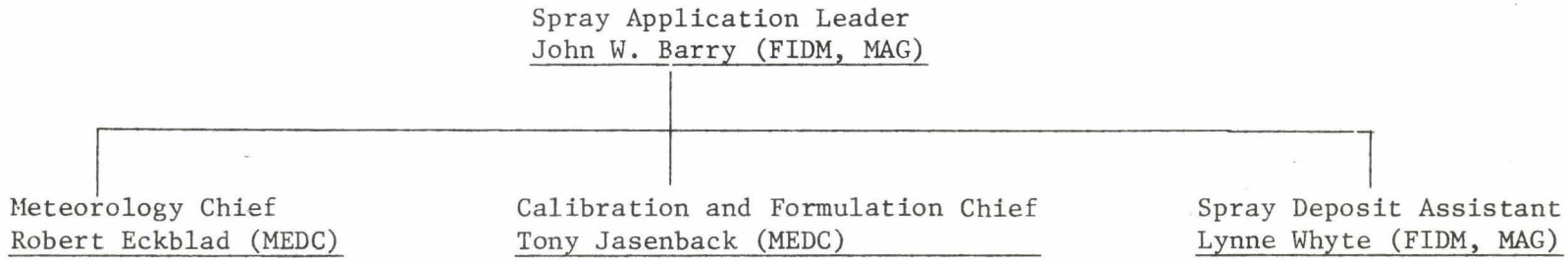


Figure 8.--Spray application organization for the western spruce budworm suppression and evaluation project, Santa Fe National Forest, 1977.

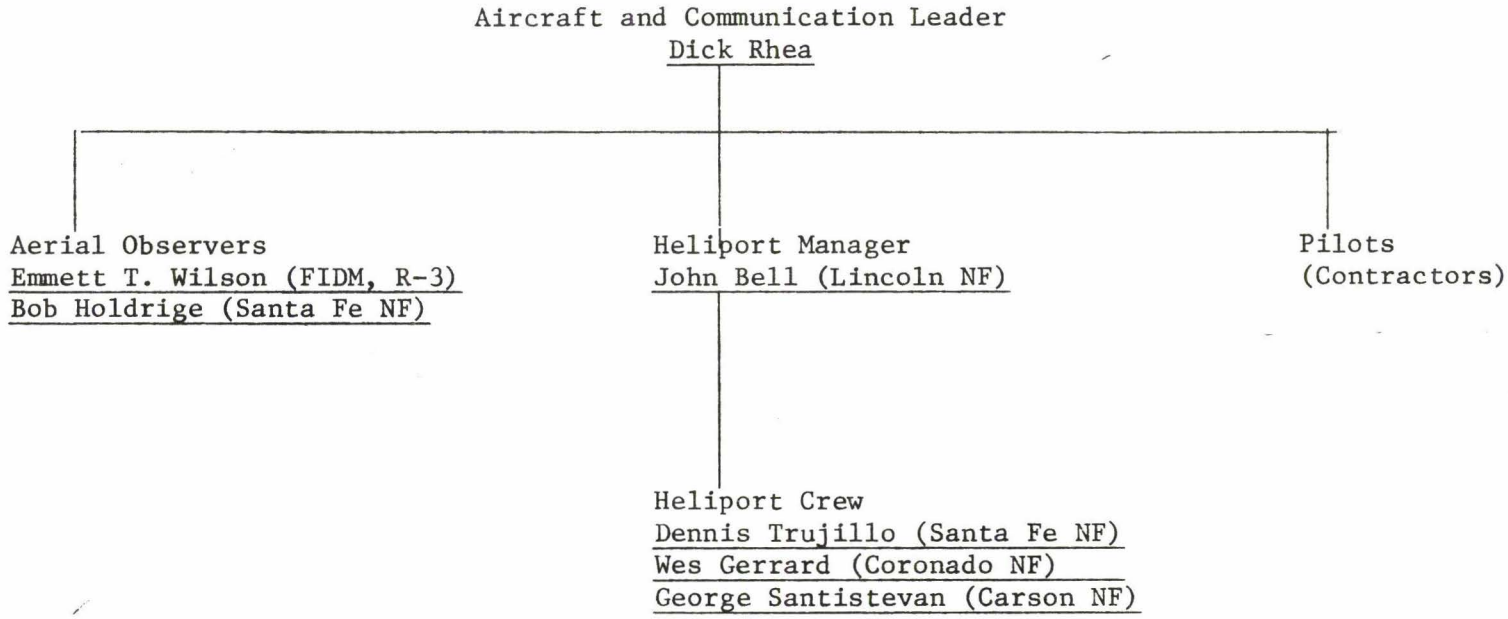


Figure 9.--Aircraft operation organization for the western spruce budworm suppression and evaluation project, Santa Fe National Forest, 1977.

		F.Y. 1977 Planned	Actual
3.	Rental Equipment and Supplies		
	a. Vehicles	11,180	13,477
	b. Headquarters and cooler	1,000	912
	c. Furniture	500	229
	d. Other	500	500
	e. Total	13,180	15,118
4.	Equipment and Supplies	16,072	13,122
5.	Personnel	46,445	40,398
6.	Administrative	51,000	40,415
7.	Services and Overhead	20,500	28,912
		337,200	319,387

E. Aerial Application

1. Type of Aircraft

Helicopters were selected for applying the Sevin®4-oil spray formulation. Helicopters were considered expensive, but fixed-wing aircraft have not been adequately tested. The use of fixed-wing aircraft would have added another undesirable variable to the project.

By contract specification, helicopters had to be able to operate at an average altitude of 8,400 feet and spray a minimum of 1,800 acres during a normal 3-hour spray day. Three helicopters were used.

a. Aerospatiale - Lama Helicopter (Fig. 10)

1. Identification Information

Registration No. N47312
Model SA315-B
Serial No. 2484
Engine Turbomecca Artouste 3B Turbine Engine
Rotor diameter - 36.15 ft. (3 blades)
Owner - AG Helicopters, Inc., Ft. Collins, CO

Figure 10.--Lama helicopter with a sling type bucket, Santa Fe National Forest, 1977.

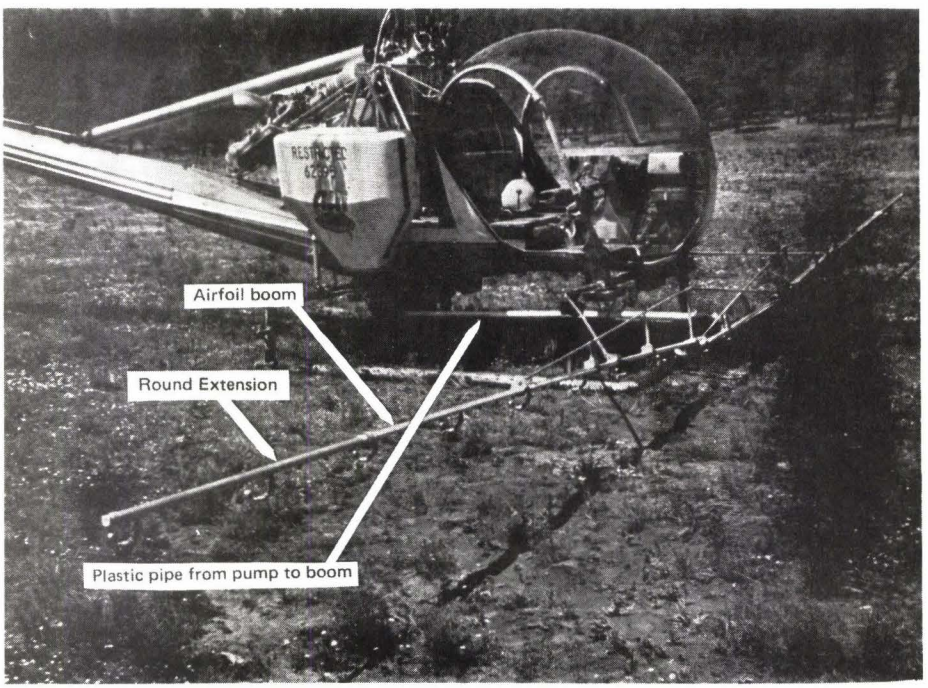


Figure 11.--Hiller helicopter (N62895) with spray system, Santa Fe National Forest, 1977.

		F.Y. 1977 Planned	Actual
3.	Rental Equipment and Supplies		
	a. Vehicles	11,180	13,477
	b. Headquarters and cooler	1,000	912
	c. Furniture	500	229
	d. Other	500	500
	e. Total	13,180	15,118
4.	Equipment and Supplies	16,072	13,122
5.	Personnel	46,445	40,398
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Model SA315-B
Serial No. 2484
Engine Turbomecca Artouste 3B Turbine Engine
Rotor diameter - 36.15 ft. (3 blades)
Owner - AG Helicopters, Inc., Ft. Collins, CO

2. Spray System

Hybrid, using Simplex Mfg. Company tanks, Chadwick, Inc., hydraulic driven pesticide pump, and toe mounted boom.

tanks - Manufactured by Simplex. 100 gallon fiberglass, top filling, electric operated dump valve.

boom - Length is approximately 40 feet. It is toe mounted and is capable of being folded. It is made of aluminum and is airfoil shaped (1-1/4 inch equivalent diameter) except for the 1-inch diameter round extensions on each end which are 4-foot long. The main airfoil shaped portion of the boom contains a center section and a left and right outboard section. The center section is approximately 8 feet long and contains 13 each 1/4-inch ports approximately 6-1/2 inches apart. Each outboard section is approximately 12 feet long and contains 23 each 1/2-inch ports spaced 6-1/2 inches apart. Each 4-foot extension contains eight each 1/4-inch ports spaced 6 inches apart.

pump - A centrifugal-submerged type driven by a hydraulic system manufactured by Chadwick, Inc. Mounted in an enclosure (Fig. 12) which is actually a manifold (p.n 500-70502-9) containing inlet ports from each tank and two outlet ports, each with integral spray on/off valve; one for the right boom and one for the left boom which would allow the pilot to spray with either boom or both. In this case, one was plugged and the other was connected by a 1-1/4 inch schedule 40 plastic pipe to the toe mounted boom.

c. Hiller Helicopter (Fig. 13)

1. Identification Information

Registration No. N65148
Model UH-12E J3 (Converted UH-12E)

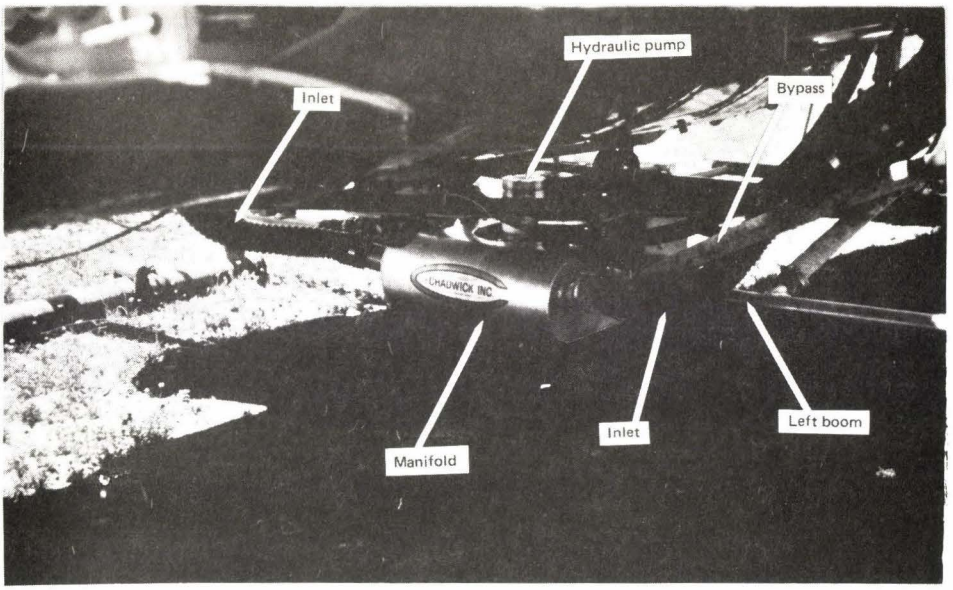


Figure 12.--Hiller helicopter (N65148) showing the pump, Santa Fe National Forest, 1977.

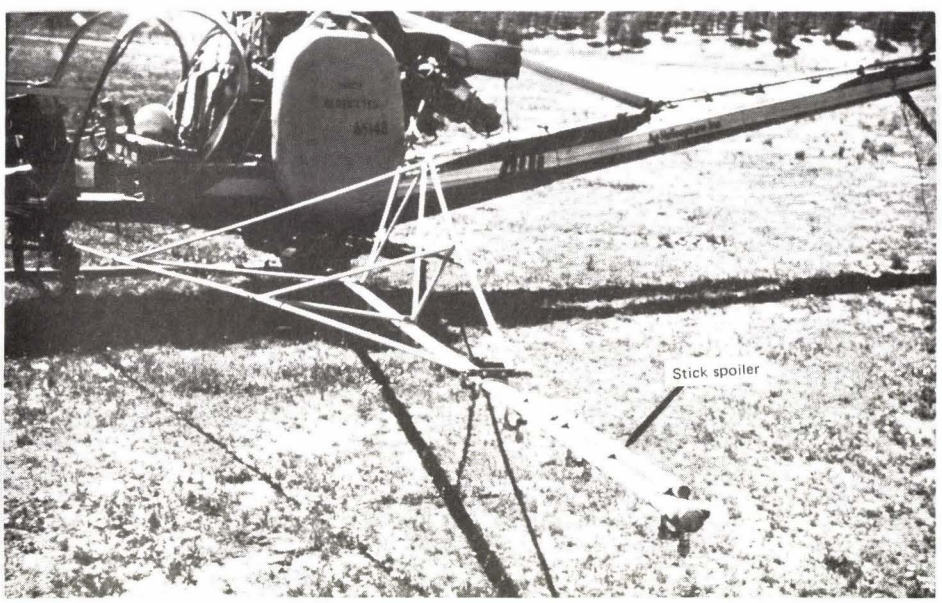


Figure 13.--Hiller helicopter (N65148) with spray system and stick spoiler, Santa Fe National Forest, 1977.

Rotor diameter - 35.4 feet (2 blades)
Engine - Allison Gas Turbine Model 250-C20
rated 400 SHP
Owner - AG Helicopters, Inc., Ft. Collins, CO

2. Spray System

Hybrid, using Transland Aircraft tanks and Chadwick, Inc. hydraulic driven pesticide pump and booms.

tanks - 100 gallon fiberglass, top filling, electric operated dump valve.

boom - left and right boom attach directly to the integral pump and manifold located below the engine. Aft of the rear cross tube, there is a short right and left center boom, fed by the respective main boom (Fig. 14).

Boom length is approximately 48 feet and is made of aluminum. The main (left and right boom is airfoil shaped (1-1/4 inch equivalent diameter) and contains 76 each 1/8-inch ports on 6-inch center, all located outboard of the helicopter skid. The left and right center section booms are 1-inch in diameter, each approximately 3-1/2 feet long containing 8 each 1/8-inch ports on 6-inch spacings.

pump - Centrifugal-submerged type driven by a hydraulic system, manufactured by Chadwick, Inc. The pump is mounted in a manifold (Fig. 13) (p/n 500-70502-9) containing inlet ports from each side tank and two boom outlet ports, each with integral spray on/off valve. This allows the pilot to spray with either boom separately or with both booms as was the case on this project.

2. Ground Handling Equipment

The ground handling equipment (Fig. 15) consisted of: Sevin®-4-oil concentrate transfer pump and meter, mixing tanker and recirculating pump, and aircraft transfer pump and meter.

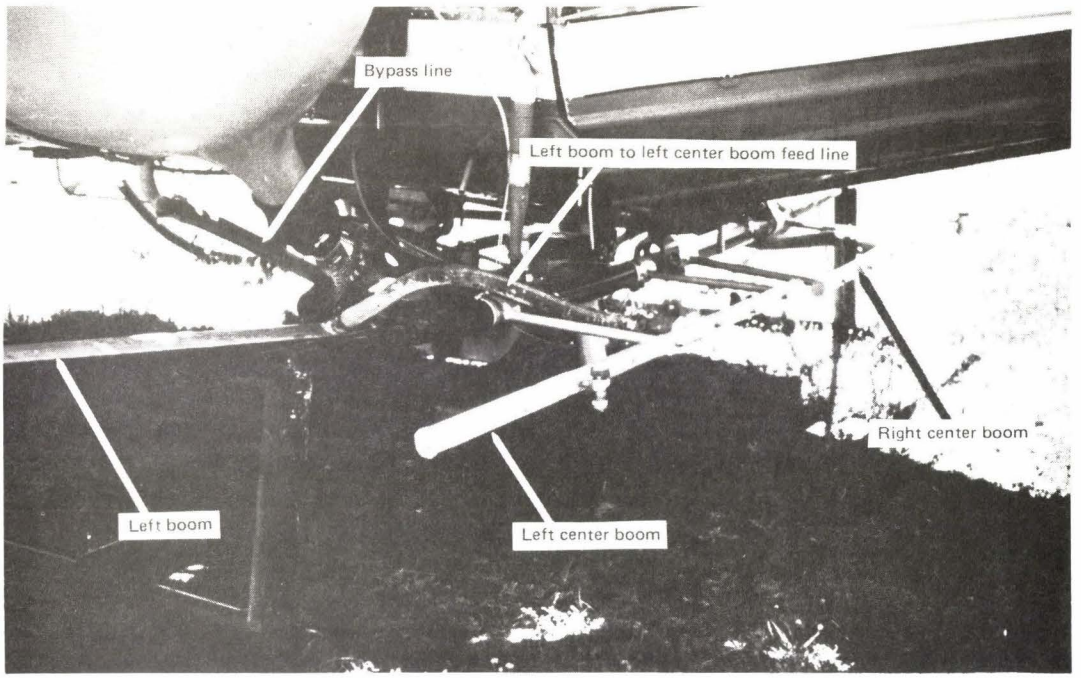


Figure 14.--Spray system on Hiller helicopter (N65148) showing center booms, Santa Fe National Forest, 1977.

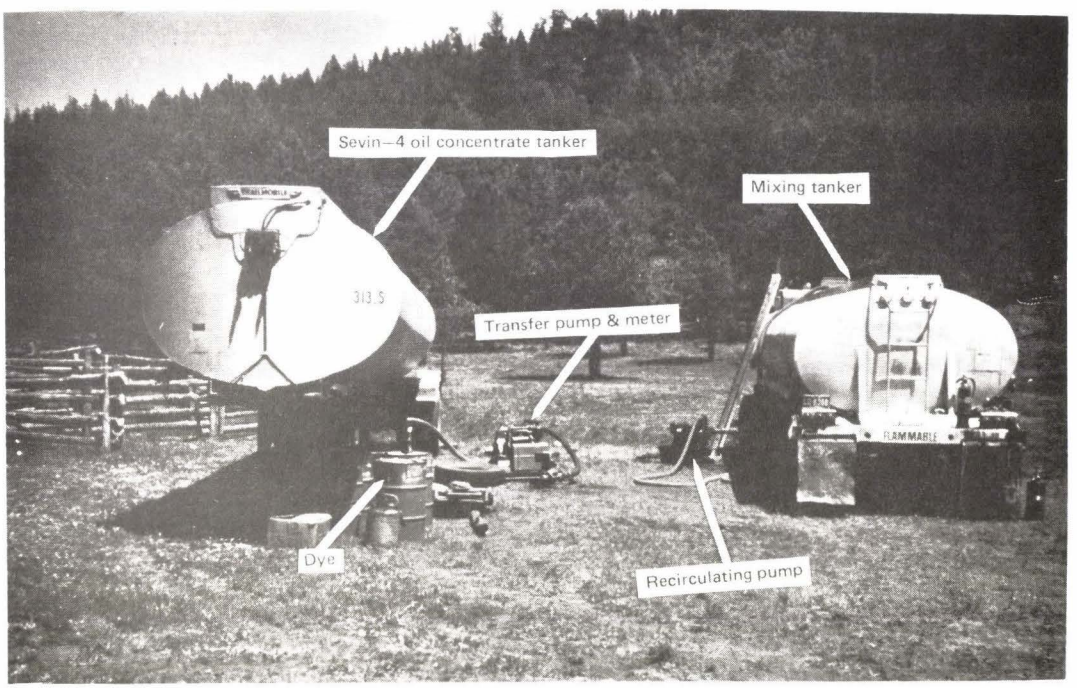


Figure 15.--Ground handling equipment, Santa Fe National Forest, 1977.

a. Transfer pump and meter

Pump:

Mfg. - Roper Pump Co.
Model - Fig. 3622 HBFL WRV
Type - Gear pump
S/N - 388678
Connections - 3-inch inlet and outlet
Engine - 16 HP, Wisconsin, Model TJD Spec. 374406,
s/n 5249010

Meter:

Mfg. - A.O. Smith Meter Co.
Model - AT 10
Connections - 2-inch inlet and outlet
Capacity - 100 GPM

b. Mixing Tanker

Semi-trailer with five separate compartments/tanks and a useful capacity of 4090 gallons. Tanks are numbered front to rear:

Tank No. 1 (Front) - contained aviation fuel, therefore, not used.

Tank No. 2 - Capacity 740 gallons, useful capacity 500 gallons.

Tank No. 3 - Capacity 1090 gallons, useful capacity 960 gallons.

Tank No. 4 - Capacity 1250 gallons, useful capacity 1180 gallons.

Tank No. 5 (Rear) - Capacity 1520 gallons, useful capacity 1450 gallons.

c. Recirculating pump

Mfg. - Gorman Rupp, Inc.
Model - 13A2 trash pump
Type - Centrifugal
s/n - 634969
Connections - 2-1/2 inch inlet and outlet
Engine - 9 HP, Wisconsin Model AENLD, Spec. 156436
s/n 5661216

d. Aircraft transfer pump and meter (Fig. 16)

These were mounted under the mixing tanker. The make and model of the pump and meter are unknown.

3. Spray Formulation

Each gallon of Sevin®-4-oil spray formulation contained the following:

0.50 gallon Sevin®-4-oil concentrate (containing 2 lbs. active ingredients)
0.48 gallons of carrier (diesel fuel no. 2)
0.02 gallons of dye (Automate Red "B")
1.00 gallon

This formulation was applied at the rate of 1/2 gallon per acre, or at the rate of 1 lb. active ingredient per acre.

4. Mixing Procedure

The following procedure was used to mix the formulation:

Add specified amount of diesel to the mixing tank.
Add specified amount of Sevin®-4-oil concentrate to mixing tank.
Add specified amount of dye to mixing tank.
Recirculate until mixed thoroughly.

The diesel fuel was first metered into the mixing tank then the transfer pump was used to transfer the Sevin®-4-oil concentrate from the delivery tanker into the mixing tank. As the concentrate was being added, the dye was also added and at the same time the recirculating pump was circulating the mixture to insure a uniform mix.

The specific amount of dye to be added to the mixing tank was measured out in graduated bucket and dumped into the mixing tank.

Duration of recirculation depended on the amount of material in the tank but in general it lasted 10 to 15 minutes after all the ingredients had been added. The adequacy of the mixing was always checked by inserting a stick into the mixing tank and after removing it looking for any changes in consistency. Also, if the formulation set over night, prior to loading the aircraft in the morning, it was again recirculated to insure uniformity of the mix.

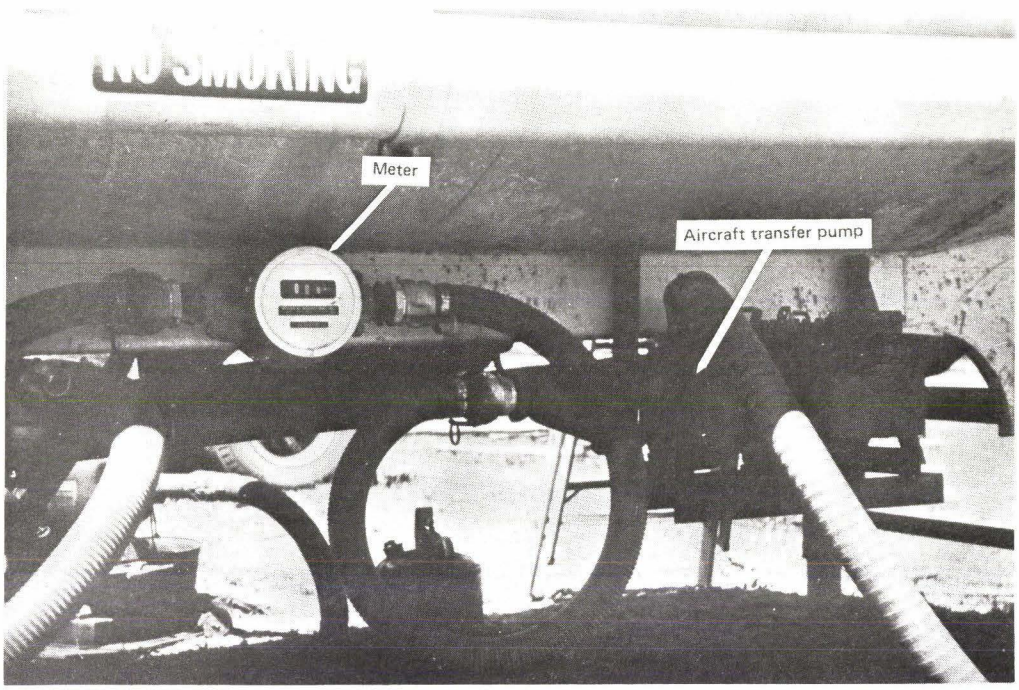


Figure 16.--Aircraft transfer pump and meter, Santa Fe National Forest, 1977.

5. Calibration

The Hiller spray systems were calibrated for a speed of 70 MPH, 1/2 GPA and a 125 ft. swath. This required each spray system to deliver the following flow rate:

$$\text{Flow rate (Hiller)} = \frac{(1/2 \text{ GPA})\ (70 \text{ MPH})(125 \text{ ft})}{495} = 8.84 \text{ GPM}$$

The Lama spray system was calibrated for a speed of 70 MPH, 1/2 GPA and a 200 ft. swath width. This required the spray system to deliver the following flow rate:

$$\text{Flow rate (Lama)} = \frac{(1/2 \text{ GPA})\ (70 \text{ MPH})\ (200 \text{ ft})}{495} = 14.14 \text{ GPM}$$

The number of nozzles required for the Lama spray system is based on the following: A required flow rate of 14.14 GPM; operating at a pressure of 50 PSIG; using 8006 spray tip with a flow rate of 0.67 GPM (based on water and a pressure of 50 PSIG); and a flow rate correction factor of 1.05 (1.05 is a calculated correction factor, however, the insecticide manufacturer recommended 1.1, therefore 1.1 was used when the 8006 spray tips were replaced with 8004 spray tips).

$$\text{No. of nozzles} = \frac{\text{system flow rate}}{\text{flow rate/spray tips X correction factor}}$$

$$= \frac{14.14 \text{ GPM}}{0.67 \text{ GPM/spray tip X } 1.05}$$

= 20 spray tips (use 20 each 8006 spray tips at 50 PSIG)

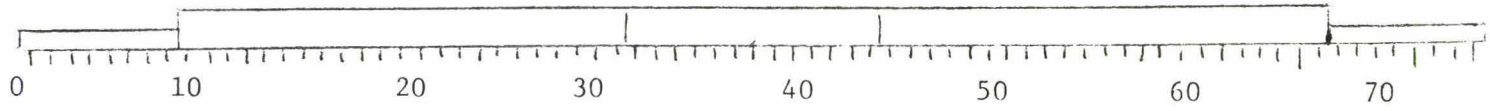
The same procedure was used to calculate the number of nozzles required for the other spray systems.

Calibration of the spray systems was accomplished by installing the required number of nozzles and setting the specified boom pressure by using a calibrated pressure gauge. While setting the boom pressure, each spray tip was observed for uniformity of spray pattern. If any were found defective, they were replaced. Also, periodically during the project, the calibration was checked by noting the time required to spray a known quantity of material. No record of these times or quantities were kept but the checks made varified the calibration.

6. Nozzle Arrangement

Due to the fact that the spray system for each helicopter is different, the location of the nozzles on the booms are shown in Figures 17 and 18. The spray system and the particular aircraft it was installed on is identified by the aircraft registration number.

Hiller N62395

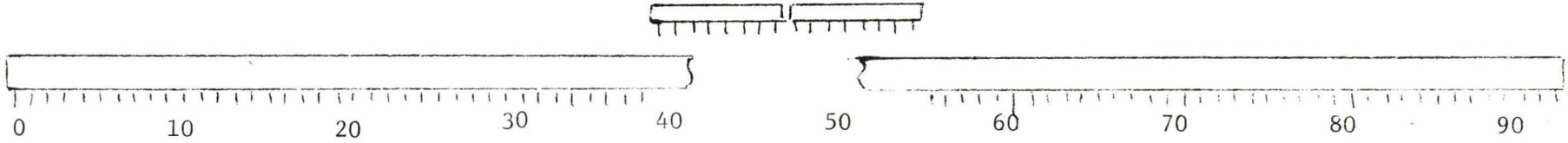


Nozzle Position 7 & 8 June; 8006 spray tips at 40 to 50 psig, orientated 45° Fwd & down
1, 5, 9, 15, 21, 27, 35, 40, 49, 55, 61, 67, 71, 75

Nozzle Position 9-12 June; 8006 spray tips at 50 psig, orientated vertical
1, 5, 9, 15, 21, 27, 38, 49, 55, 61, 67, 71, 75

Nozzle Position 13-19 June; 8004 spray tips at 40 psig, orientated vertical
1, 5, 9, 13, 17, 21, 25, 29, 33, 36, 40, 43, 47, 51, 55, 59, 63, 67, 71, 75

Hiller N65148



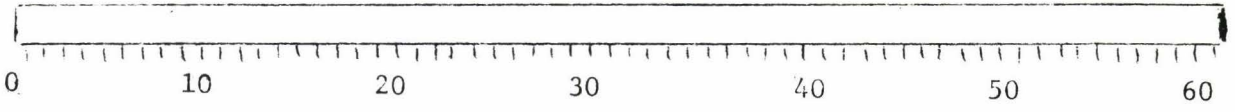
Nozzle Position 7 & 8 June; 8006 spray tips at 40 to 50 psig, orientated 45° Fwd & down
1, 5, 15, 21, 29, 35, 41, 52, 58, 64, 72, 78, 88, 92

Nozzle Position 9-12 June; 8006 spray tips at 50 psig, orientated vertical
1, 5, 15, 21, 29, 35, 41, 58, 64, 72, 78, 88, 92

Nozzle Position 13-19 June; 8004 spray tips at 40 psig, orientated vertical
1, 5, 9, 13, 17, 21, 25, 29, 33, 41, 52, 60, 64, 68, 72, 76, 80, 84, 88, 92

Figure 17.--Spray nozzle arrangement for Hiller helicopters, Santa Fe National Forest, 1977.

Lama N47312



Nozzle Position 7 & 8 June; 8006 spray tips at 40 psig, orientated 45° Fwd & down
1, 3, 5, 8, 13, 16, 19, 21, 24, 26, 30. 32, 36, 38, 41, 43, 46, 49, 54, 57, 59, 61

Nozzle Position 9-12 June; 8006 spray tips at 50 psig, orientated vertical
1, 3, 5, 8, 13, 16, 19, 21, 24, 26, 36, 38, 41, 43, 46, 49, 54, 57, 59, 61

Nozzle Position 13-19 June; 8004 spray tips at 40 psig, orientated 45° Fwd & down
1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 28, 34, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 60, 61

Figure 18.--Spray nozzle arrangement for Lama helicopter, Santa Fe National Forest, 1977.

7. Log of Calibration and Formulation Chief

6 June 77 - Inspected spray systems

7 June - Installed spray tips, attempted to calibrate systems but due to plugged nozzles, loose connections and not being able to get the Lama spray system engine started, was unsuccessful.

8 June - Characterization of spray system.

9 June - Changed the number of nozzles on the respective systems and adjusted the boom pressure to 50 PSIG. Begin formulating Sevin®-4-oil, moved to helispot in Barley Canyon (Fig. 19).

10 June - Sprayed part of subunit 6. Applied 1572 gallons of insecticide. Hiller spray system N65148 developed crack in pump manifold. Lama sling system developed leak in "y" strainer.

11 June - Sprayed subunits and part of subunit 6. Applied 2746 gallons of insecticide. Noted considerable spray beginning to collect on boom of Lama sling system. After spraying, heliport was moved to abandoned highway south of Cuba, New Mexico (Fig. 20).

12 June - Sprayed part of subunit 2. Applied 1747 gallons of insecticide. Changed spray tips from 8006 to 8004 on all systems. Added 3" pipe nipple between boom and nozzle on Lama sling system to prevent spray from collecting on boom.

13 June - Completed subunit 2. Applied 1331 gallons of insecticide. Lama had engine trouble. Spray tip caps on all systems were loose and had to be tightened. Lama sling system developed leak in boom joint which had to be fixed. Tractor pulling mixing tanker lost air compressor.

14 June - Sprayed subunit 1. Applied 1802 gallons of spray. Lama sling system engine quit during first load and did not get it working again. Finished repairing tractor in the afternoon. Moved helispot back to Barley Canyon.

15 June - Sprayed subunit 4. Applied 1637 gallons of insecticide in morning and 364 gallons in the evening. Lama sling system engine would not run properly therefore, replaced engine but only got out one load. Hiller spray system N65148 broken hose between right boom and right center boom.

16 June - Completed spraying subunit 4 and started subunit 3. Applied 1882 gallons of insecticide. Lama sling system only hauled four loads today.

Figure 19.--Heliport at Barley Canyon, Santa Fe National Forest, 1977.

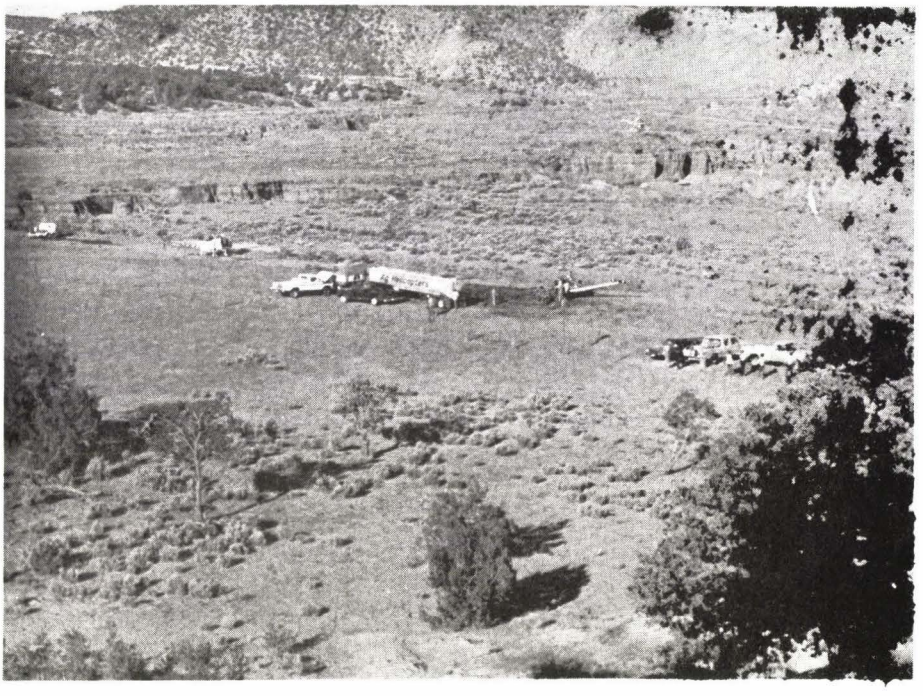


Figure 20.--Heliport on abandoned highway south of Cuba, New Mexico, Santa Fe National Forest, 1977.

17 June - Applied 2103 gallons of insecticide. Lama sling system quit after the fourth load and was not used again.

18 June - Applied 1523 gallons of insecticide.

19 June - Applied 1201 gallons of insecticide. Project complete.

8. Comments by Calibration and Characterization Chief

a. Initially a calculated flow rate correction factor of 1.05 was used to determine the number of nozzles required on each spray system. However, the insecticide manufacturer recommended a factor of 1.1 which was used when the 8004 spray tips were placed on the spray systems.

b. An error was made when the nozzles were installed on the Lama sling spray system. There should have been 32 each 8004 spray tips installed but the record shows only 31 were installed.

c. An attempt was made to use the centrifugal-recirculating pump (2-1/2 inch inlet and outlet) driven by a 9 HP engine to transfer the Sevin ® -4-oil concentrate from the delivery tanker to the mixing tanker. However at full throttle it lugged down badly and would only pump about 28 GPM, which was insufficient (after the concentrate had been diluted 50 percent by diesel fuel the pump worked fine). After the unsuccessful attempt with the centrifugal pump to transfer the Sevin ®-4-oil concentrate, a gear type pump with 3-inch inlet and outlet, driven by a 16 HP engine was used. It pumped approximately 100 GPM at about 1/4 throttle, which was sufficient.

d. The engine on the Lama sling spray system continually gave problems throughout the project and never was completely fixed even though numerous attempts were made to do so.

e. The nozzles on the Lama sling system were located so close to the boom that when they were oriented 45 degrees forward and down, spray began to collect on the boom. This was solved by placing a 3-inch pipe nipple between the boom and nozzle.

f. An attempt was made to raise the tip ends of the boom on the Lama sling system a couple of feet above the ground to reduce the possibility of the tips hitting the ground during take-off and landing. However, when the tips were raised, they also inclined forward and in flight the system tended to swing radically. Therefore, they had to be lowered back to their original position, which was stable in flight.

g. On both the Hiller spray systems, the nozzles were originally oriented 45 degrees forward and down; however, after the first spray flight, the aft side of all the nozzles were heavily covered with spray. The pilots indicated that the Hiller helicopter flew relatively flat (did not tend to nose over) in flight and the nozzles were therefore rotated too far forward. Reorienting the nozzles to the vertical position solved the problem.

h. When the pressure on Hiller spray system No. N62395 was adjusted for 50 PSIG, the bypass into the bottom of the tank would squirt insecticide out the tank lid when the tank was nearly empty. This was solved by rebending the deflector plate provided inside the tank for this purpose.

i. The pilot of Hiller No. N65148 indicated the ends of the airfoil shaped boom were creating lift which he could feel in the controls when maneuvering. Therefore, he taped a stick on the end of each boom (Fig. 13) to act as spoilers and eliminate aerodynamic lift.

j. The flow meter used to measure the amount of Sevin® 4-oil concentrate pumped from the delivery tanker, indicated the first tanker contained 4448 gallons. The tanker actually contained 4480 gallons according to Union Carbide however, this difference is about what would be expected with material left on the sides of the tanks and in hoses.

k. One of the helicopter pilots also was the truck driver for the mixing tanker which would be all right if the tanker was left at one location or did not develop mechanical problems. However, in this case the tanker was moved several times and in the process the tractor broke down and the pilot spent many frustrating hours repairing it.

9. Spray Characterization Trials

Characterization trials were conducted on June 8, 1977, on a relatively flat area on Cuba Mesa, Cuba Ranger District. Temperature, humidity, wind speed, and wind direction were continually checked during the trials. Smoke bombs were also used to show probable spray dispersal. A card line was layed at a right angle to the wind. Cards were placed at 10-foot intervals along this line. Helicopters were instructed to fly across the card line at 70 miles per hour and about 50 feet above the ground. After waiting a few minutes, cards were retrieved and the density and size of drops were checked. The effective spray swath of each helicopter was determined by counting cards which had at least eight drops per cm^2.

Table 1 provides data on observations made in the field during the characterization. Characterization trials could not be completed during the favorable spray weather associated with early morning hours, and there was no time available to conduct additional characterization trials the following day. The first four trials were conducted under conditions acceptable for obtaining spray characterization data. Tables 2, 3, and 4 give the droplet size distribution for the three aircraft.

10. Spray Deposit Assessment

White Kromekote cards were used to monitor spray drift and deposition of the dyed (Automate Red B) spray in forest openings, around trees sampled for larval reduction, and near streams and other areas where there were concerns about the environmental effects of the treatment. Cards were held in plastic holders and were placed on the ground (Fig. 21). Cards were positioned at cardinal directions at the drip line around trees sampled for larval reduction in an attempt to obtain data on spray behavior (Fig. 22). Each three-tree cluster required 12 cards. A Quantimet image analyzer was used. Averaging the droplet count and mass (gallons/acre) on all cards in a subunit yielded an estimate of the insecticide application.

Mass recovery data, shown in Table 5, exceeds the planned application rate of 1/2 gallon per acre in nine out of 12 sites sampled. However, the gallons loaded in helicopters and sprayed (Table 6) conflict with data presented in Table 5. This discrepancy is explained, in part, by the excessively large drops (leaks) on spray cards. Uneven distribution of spray over treatment subunits would be another explanation. Spray deposit cards were not evenly placed throughout subunits; therefore, it was not possible to assess the uniformity of application.

Spray deposit in meadows, along streams, etc., in treatment subunits and at the south end of the San Pedro Parks Wilderness are presented in Table 7. Spray drift reached all streams. In San Pablo Creek (Blue Bird Subunit) the stream was accidentally sprayed where the card line was located. A minute amount of spray reached the parking lot just south of the San Pedro Parks Wilderness. Deposit data, including VMD, droplet density, and mass recoveries obtained within the spray subunits, differed from that observed during the spray characterization trials (Table 1). The VMD, which is a standard and relative method of expressing and comparing drop size of the spray, was considerably higher on the spray blocks as compared to sizes estimated during the characterization trials. Spraying System Flat Fan 8006 spray nozzles were used on subunits 5 and 6. In an effort to get a smaller droplet size, 8004 nozzles were placed on all spray helicopters and these nozzles were used

Table 1.--Spray aircraft characterization trials, June 8, 1977, Santa Fe National Forest.

Aircraft	Trial	Time	Temperature (°F)	RH (%)	Field VMD (um)	Swath Width (Feet)	Release Height (Feet)	Boom Pressure (PSIG)	Remarks
Hiller N65148	1	0608	47	64	280	140-180	--	44	
Hiller N62395	2	0629	45	68	362	160-180	70	--	
Hiller N65148	3	0649	50	66	319	180-200	--	50	
Hiller N62395	4	0705	54	49	290-328	200-240	60	50	
Hiller N65148	5	0737	60	57	309	180	--	50	Met conditions marginal to poor after 0700 hours
Lama N47312	6	0755	65	49	346	160-180	60	--	
Lama N47312	7	0907	70	42	328	---	100	50	
Lama N47312	8	0926	75	39	350	60	40	50	
Hiller N65148	9	0944	78	35	280	160	40	50	

NOTE: Spray nozzle Spraying System Flat Fan 8006.
Release height varied by trial from 50' to 125' above deposit cards.
Aircraft speed 70 miles per hour.

Table 2.--Size distribution of Sevin®-4-oil spray droplets from Hiller J-3 (N65148) with Spraying Systems 8006 nozzle tips, characterization trials, Santa Fe National Forest, 1977.

Drop Size Category (um)	Percent by Drop Size	Cumulative %
39.1	16	16
74.2	13	29
109.6	12	41
142.1	11	52
174.9	11	63
209.4	8	71
241.7	5	76
273.4	5	81
304.8	4	85
334.7	3	88
367.0	2	90
397.1	2	92
421.7	.7	93
477.9	3	96
543.2	2	98
740.8	3	100

Table 3.--Size distribution of Sevin®-4-oil spray droplets from Hiller J-3 (N62395) with Spraying Systems 8006 nozzle tips, characterization trials, Santa Fe National Forest, 1977.

Drop Size Category (um)	Percent by Drop Size	Cumulative %
39.1	16	16
74.2	13	29
109.6	15	44
142.1	14	58
174.9	13	71
209.4	8	79
241.7	6	85
273.4	4	89
304.8	3	92
334.7	2	94
367.0	1	95
397.1	.7	96
421.7	.8	97
477.9	1	98
543.2	8	99
740.8	2	100

Table 4.--Size distribution of Sevin®-4-oil spray droplets from Lama 315B with a slung bucket system, and Spraying Systems 8006 nozzle tips, characterization trials, Santa Fe National Forest, 1977.

Drop Size Category (um)	Percent by Drop Size	Cumulative %
39.1	13	13
74.2	13	26
109.6	14	40
142.1	13	53
174.9	13	65
209.4	9	74
241.7	6	80
273.4	5	85
304.8	3	87
334.7	2	89
367.0	2	90
397.1	1	92
421.7	1	92
477.9	4	96
543.2	2	98
740.8	2	100

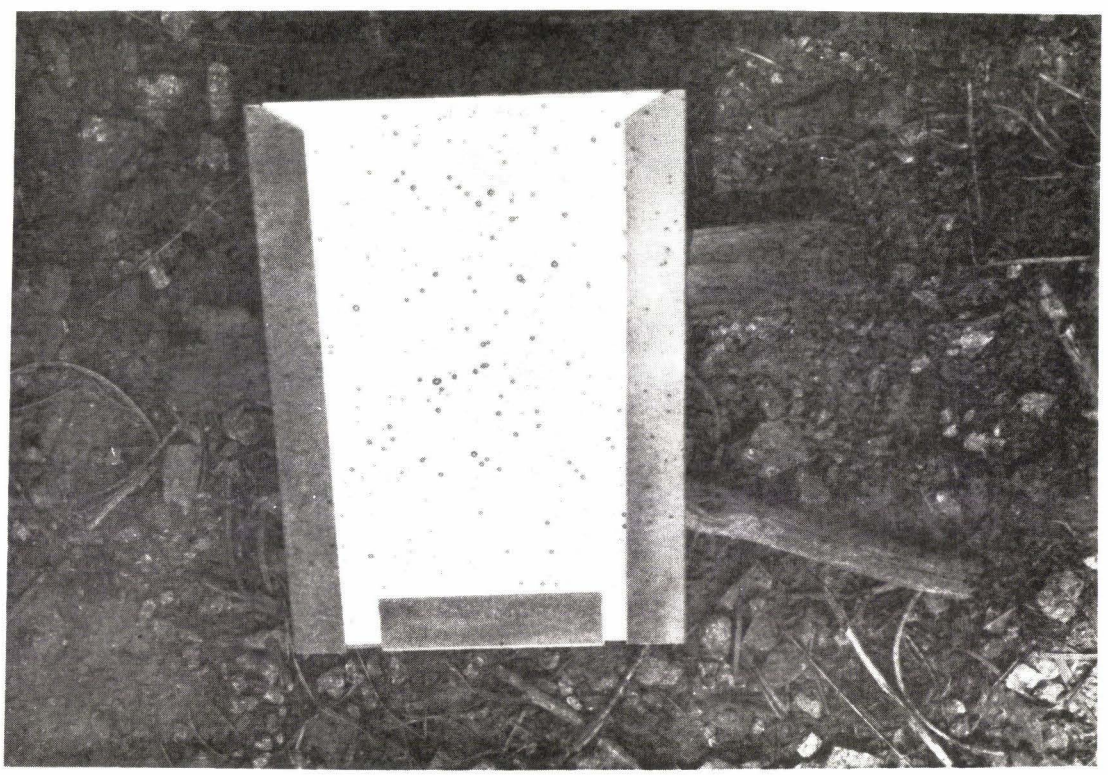


Figure 21.--White Kromekote card in a plastic holder with spray deposit, Santa Fe National Forest, 1977.

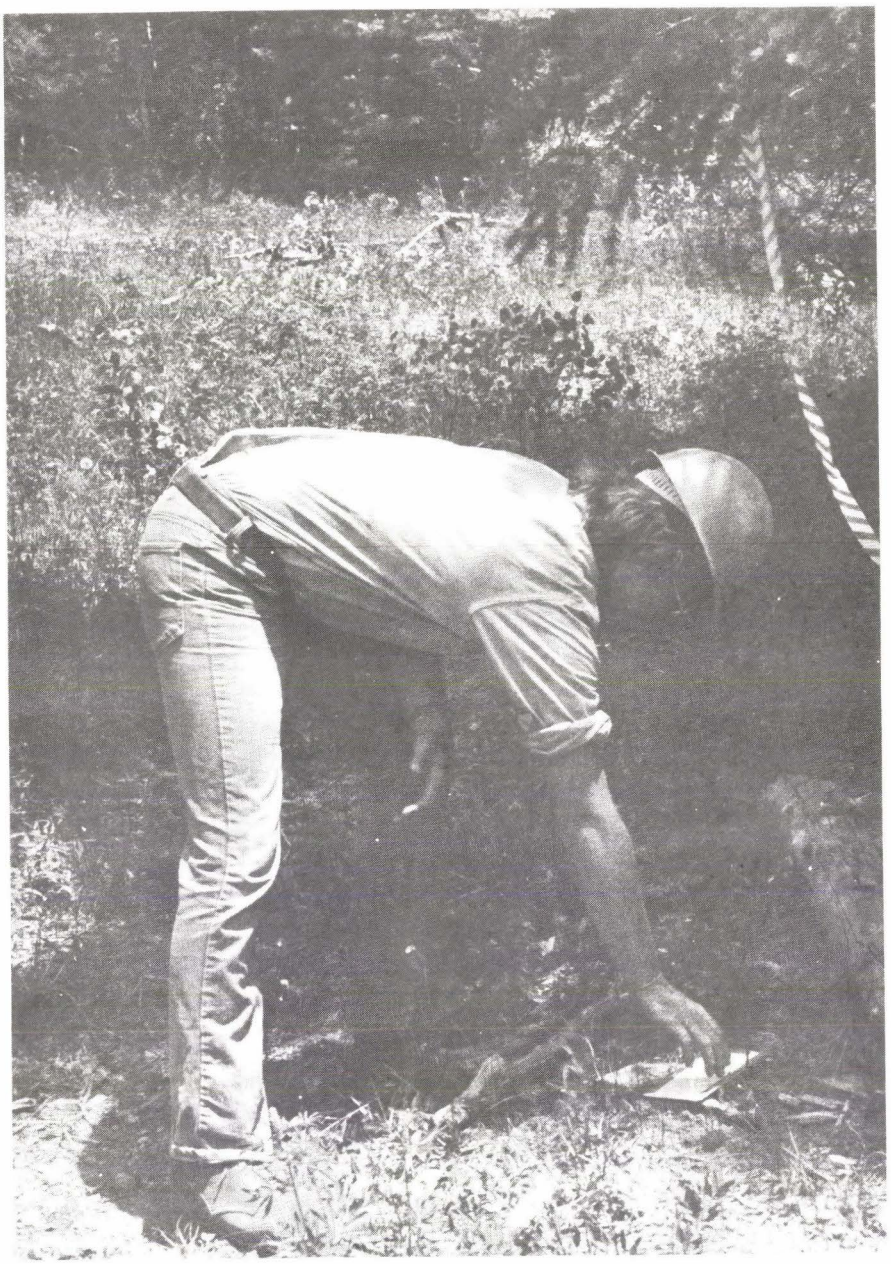


Figure 22.--Placement of the spray card at the drip line around a tree sammpled for larval reduction, Santa Fe National Forest, 1977.

Table 5. Summary of spray deposit data, Santa Fe National Forest, 1977.

Spray Subunit	Drops/ cm^2	VMD (um)	Number Mean Drop Dia. (um)	Mass Recovery gallon/acre
1 Trees	2.95	540	198	.54
Open	9.03	478	161	.83
2 Trees	3.19	483	188	.40
Open	9.05	385	95	.22
3 Trees	3.83	508	204	.61
Open	8.67	547	253	2.30
4 Trees	4.35	541	198	.73
Open	8.83	503	174	1.06
5 Trees	5.68	546	192	.87
Open	6.6	548	182	.93
6 Trees a/	2.2	557	185	.31
Open	3.84	540	184	.53

a/ Subunit 6 was resprayed. Deposit data reflects deposit for first application only.

Table 6. Actual gallons of Sevin(R)-4-oil load in helicopters and sprayed in each subunit, Santa Fe National Forest, 1977.

Spray Subunit	Acreage	Gallons Planned for Spraying	Actual Gallons Sprayed	Actual Gallons per acre
1	6,288[a]	3,144	1,962	0.31
2	5,755	2,877	2,918	0.51
3	6,613	3,307	3,336	0.50
4	6,388	3,194	3,209	0.50
5	6,928	3,464	2,586	0.37
6[b]	5,478	2,739	3,897	0.71
Total	37,450	18,725	17,908	0.48

a/ Plans were to treat 6,288 acres but a smaller area, which cannot be determined, was not treated.

b/ This subunit was sprayed twice. The total gallons sprayed in this subunit is presented.

Table 7. Deposit data from cards placed in open areas, Santa Fe National Forest, 1977.

Subunit Number	Location	Number of Cards	VMD (um)	Drops/cm^2	Ounce/Acre	Gallon/Acre
1	Undetermined	49	503	7.4	99	.77
1	East - San Migual Lookout	17	318	7.3	59	.46
1	Undetermined	25	482	13.4	139	1.08
2	Undetermined	25	526	.7	33	.26
2	Undetermined	20	476	.3	8	.06
2	North Half	49	166	18.5	14	.11
2	South Half	23	366	5.5	36	.28
3	Undetermined	86	550	9.5	321	2.51
3	Near Tree 196	12	439	2.7	39	.31
4	Meadow	26	472	12.5	169	1.09
4	Undetermined	7	617	14.0	498	3.89
4	Undetermined	34	496	9.2	160	1.25
4	Undetermined	18	225	1.4	1.5	.01
4	Undetermined	17	442	6.4	89	.70
4	Stream Near Tree 238	12	183	11.3	12	.09
5	Upper Edge San Pablo	25	268	12.5	35	.27
5	Big Mountain	23	534	6.9	188	1.47
5	Clear Creek	10	224	.4	.8	.01
5	Eureka Mesa	10	198	.2	.3	.002
5	San Pedro Parks Wilderness Parking Lot	7	167	.2	.2	.002
5	San Pablo Creek (Road every 1/10 mile)	19	493	4.4	53	.41
5	Blue Bird Mesa	29	555	12	258	2.01
5	Blue Bird Mesa	15	723	1.6	56	.44
5	East, Center	15	580	5.0	211	1.65
6	Center	25	570	6.5	66	.52
6	South, Center	25	545	5.6	155	1.21
6	North	49	220	1.7	4	.03
6	Undetermined	24	542	3.7	98	.77

on subunits 1 to 4. The largest aerodynamic drop observed on deposit cards exceeded 900 um on each spray block and the maximum drop size ranged from 900 um to 2,984 um (Table 8). These excessively large sizes, in all probability, indicate leaks in the spray systems. Leaking was observed at the loading site. Another interesting observation was the range of maximum drop size from one block to another. This again reflects variability in equipment operation. Leaks are more likely to develop during sustained operations when systems are placed under stress than during short periods required to conduct characterization.

In general, the spray deposit data show that there was adequate coverage of the sample tree clusters even though the drop density was low and the VMD (drop size) was large. The coverage was sufficient to reduce the budworm larval population by over 90 percent.

Spray deposit data also provided opportunities to expand the data base on spray behavior. One type of analysis which can be performed on these data is plotting percent of spray drops, by drop size category, which penetrate the tree canopy and deposit on the forest floor. This is done by plotting ratio of drops observed beneath trees to drops collected in open areas. As an example, if the same number of 100 um drops were observed on cards around trees and in open areas, the ratio would be 1:1 and one would conclude that no drops of that size were scavenged by the foliage. Data presented in Figures 23 to 28 show that drops in the 150 um range were more efficiently scavenged by the foliage than drops less than 100 um or greater than 400 um. It should be noted that drops less than 100 um are not efficiently collected by Kromekote cards or analyzed by Quantimet image analyzer. Data collected from other experiments show that drops less than 100 um are effectively scavenged by coniferous foliage.

11. Airborne and Fallout Drift

Agricultural Engineers, University of California, Davis, California, monitored airborne and fallout drift under a study funded by the Douglas-fir Tussock Moth Research and Development Program.[2/] Their objectives were to: 1) determine the drop size frequency and total volume of airborne and fallout insecticide spray drift loss under a mountainous forest canopy conditions, 2) monitor air burden of spray materials outside of spray area, down slope for up to 4 miles distance, and 3) collect certain meteorological data necessary to correlate the movement of sprays and deposits.

2/ Akesson, Norman B. and Wesley E. Yates. 1977. Douglas-fir Tussock Moth Control Program. Final report and report on 1977 Pilot Plot Tests. PNW DFTM Agreement RSW-3, 21-395. 16 USC 581a. 581a-581i.

Table 8. Three largest droplets observed on all spray deposit cards from each of 6 spray subunits, Santa Fe National Forest, 1977.

Subunit Number	Stain Size		Estimated Aerodynamic Drop Diameter (um)
	Number	Diameter (um)	
1	1	4700	997.7
	2	4400	979.1
	3	4500	986.0
2	1	5100	1013.2
	2	5100	1013.2
	3	4800	1002.6
3	1	3900	934.8
	2	3900	934.8
	3	3800	923.9
4	1	12100	2361.8
	2	11200	2184
	3	10000	1950
5	1	5200	1015.4
	2	4100	955.3
	3	4000	945
6	1	15300	2983.5
	2	11800	2301.0
	3	6600	1287.0

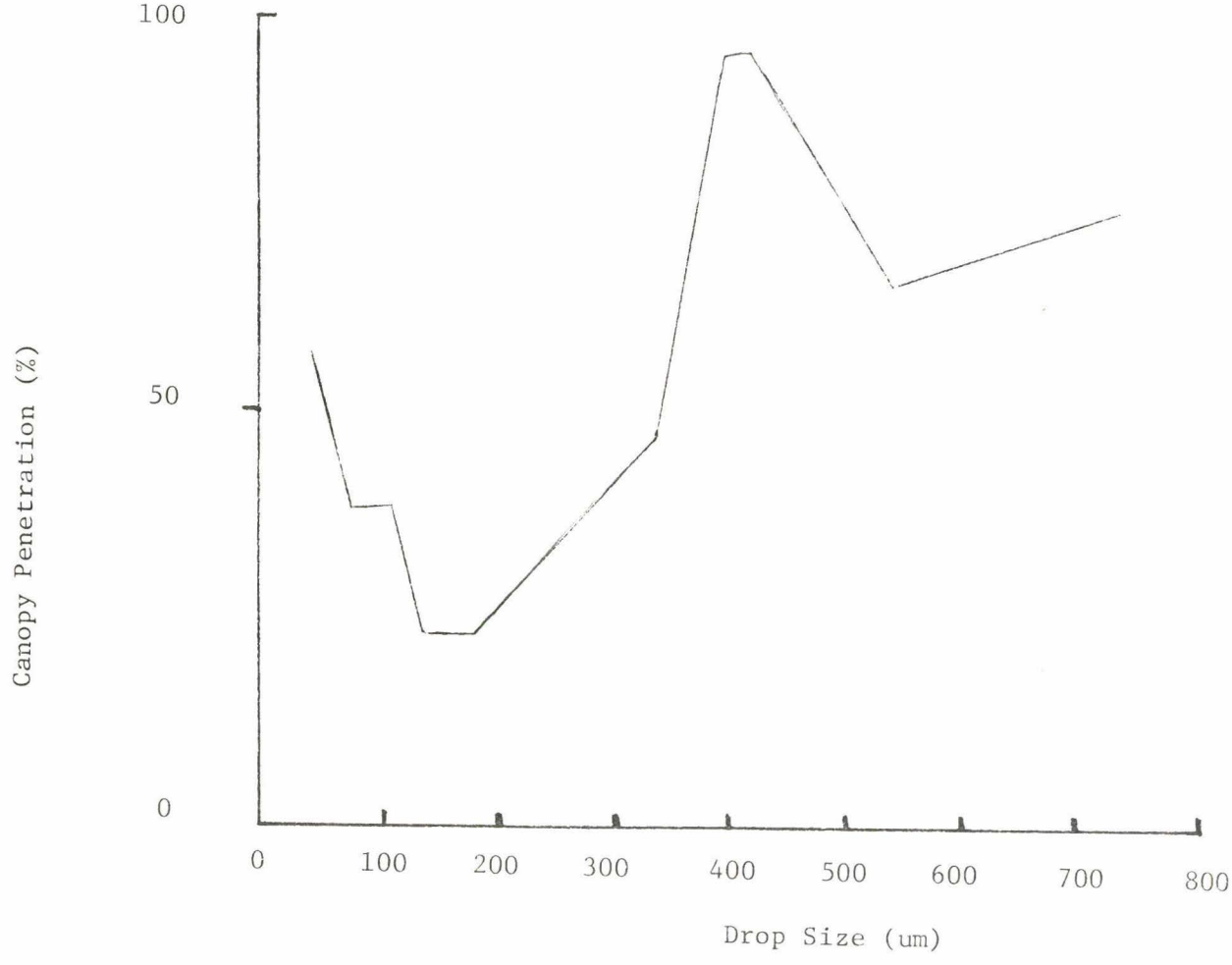


Figure 23. Subunit 1, Sevin®4-oil canopy penetration by drop size. Canopy penetration ratio drops recovered under trees to drops recovered in open areas, plotted as a function of drop size, Santa Fe National Forest, 1977.

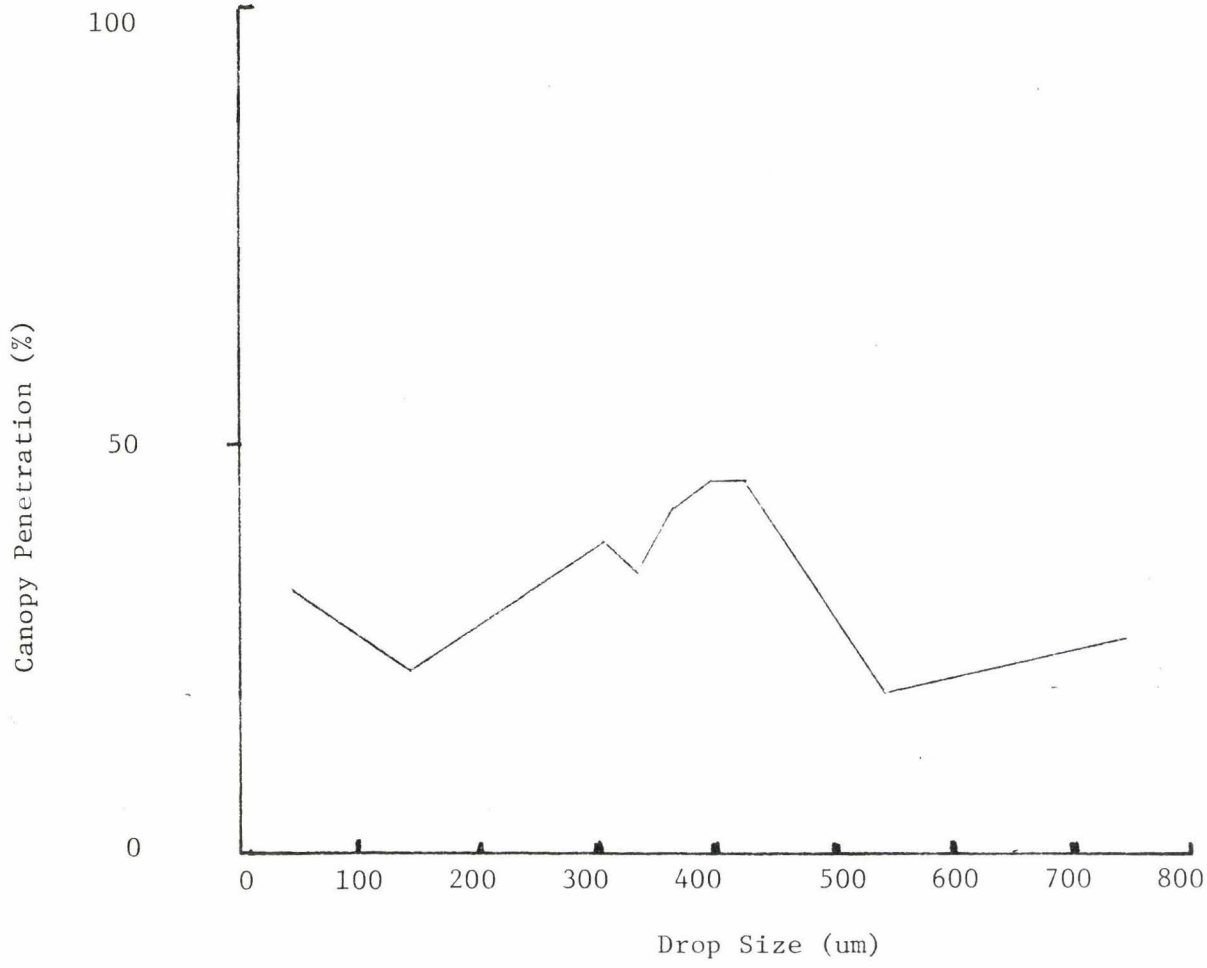


Figure 24. Subunit 2, Sevin®4-oil canopy penetration by drop size. Canopy penetration ratio drops recovered under trees to drops recovered in open areas, plotted as a function of drop size, Santa Fe National Forest, 1977.

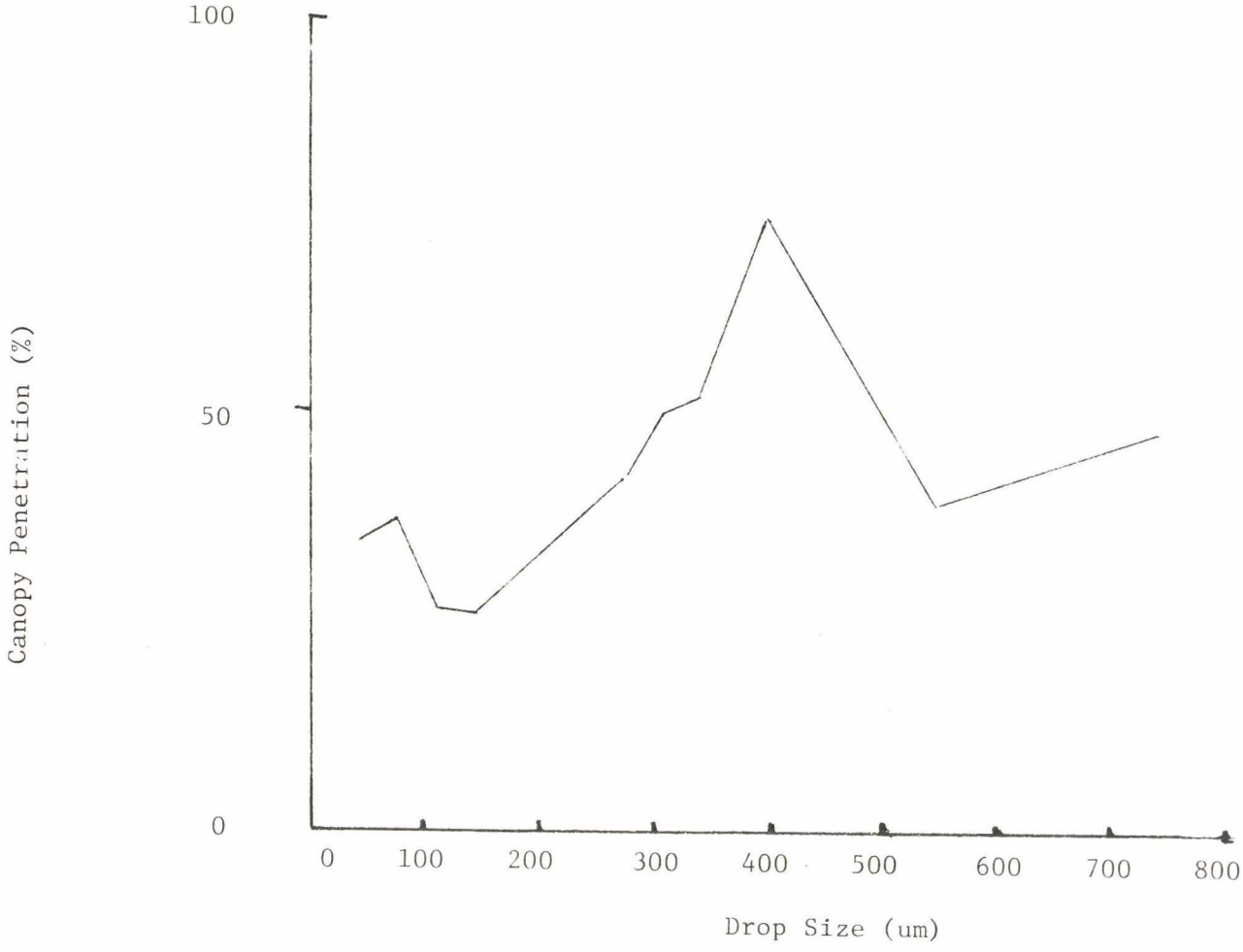


Figure 25. Subunit 3, Sevin® 4-oil canopy penetration by drop size. Canopy penetration ratio drops recovered under trees to drops recovered in open areas, plotted as a function of drop size, Santa Fe National Forest, 1977.

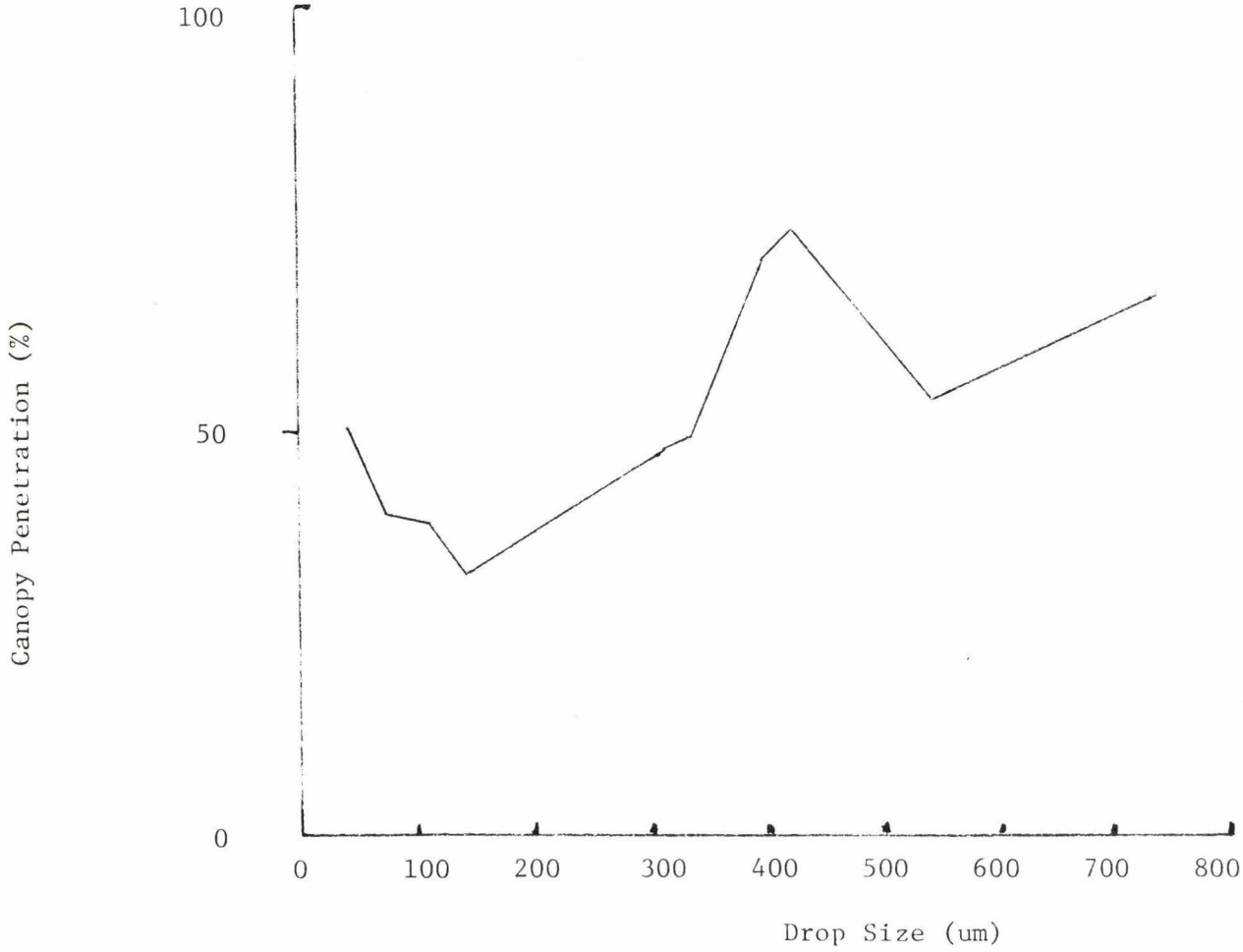


Figure 26. Subunit 4, Sevin®-4-oil canopy penetration by drop size. Canopy penetration ratio drops recovered under trees to drops recovered in open areas, plotted as a function of drop size, Santa Fe National Forest, 1977.

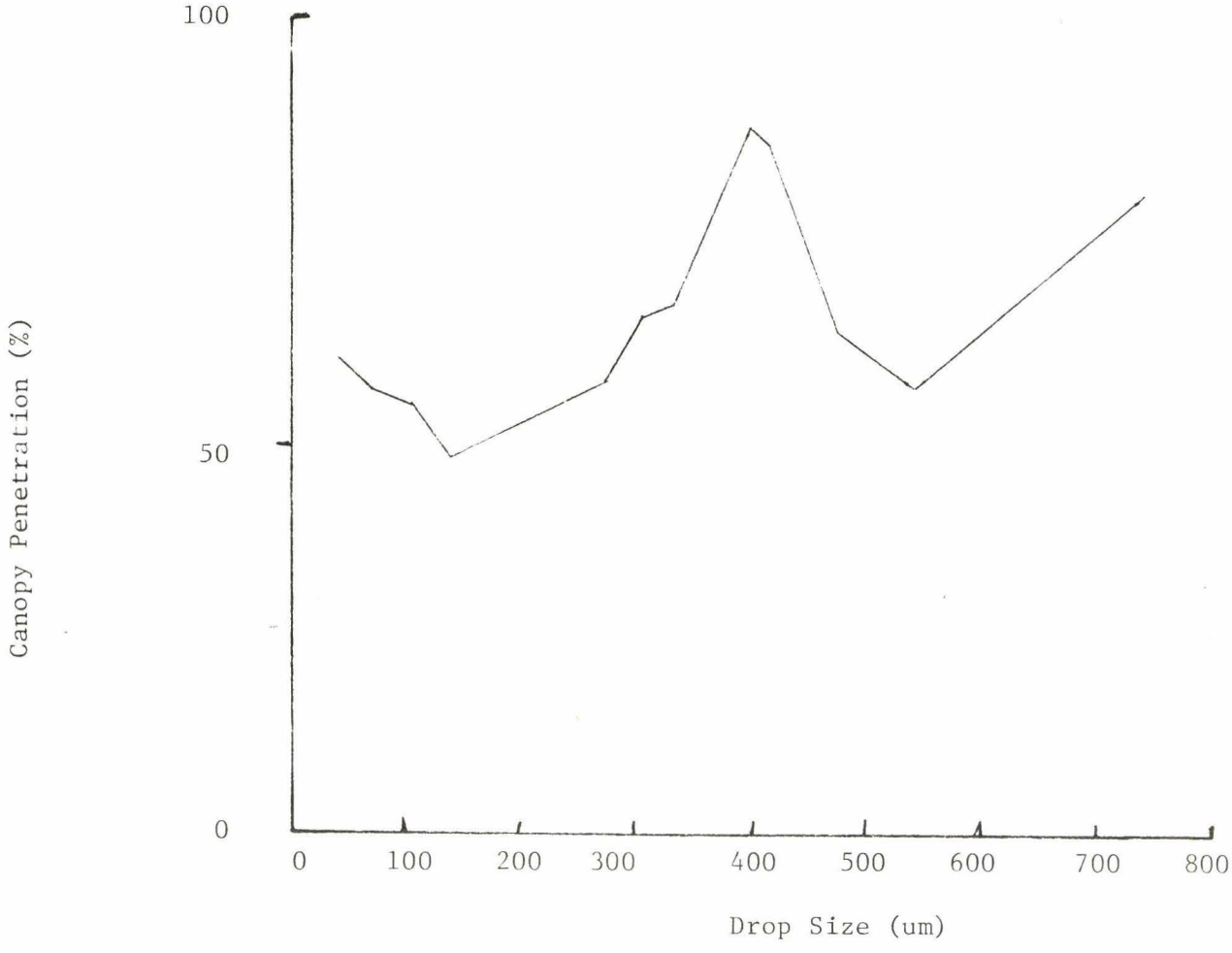


Figure 27. Subunit 5, Sevin®-4-oil canopy penetration by drop size. Canopy penetration ratio drops recovered under trees to drops recovered in open areas, plotted as a function of drop size, Santa Fe National Forest, 1977.

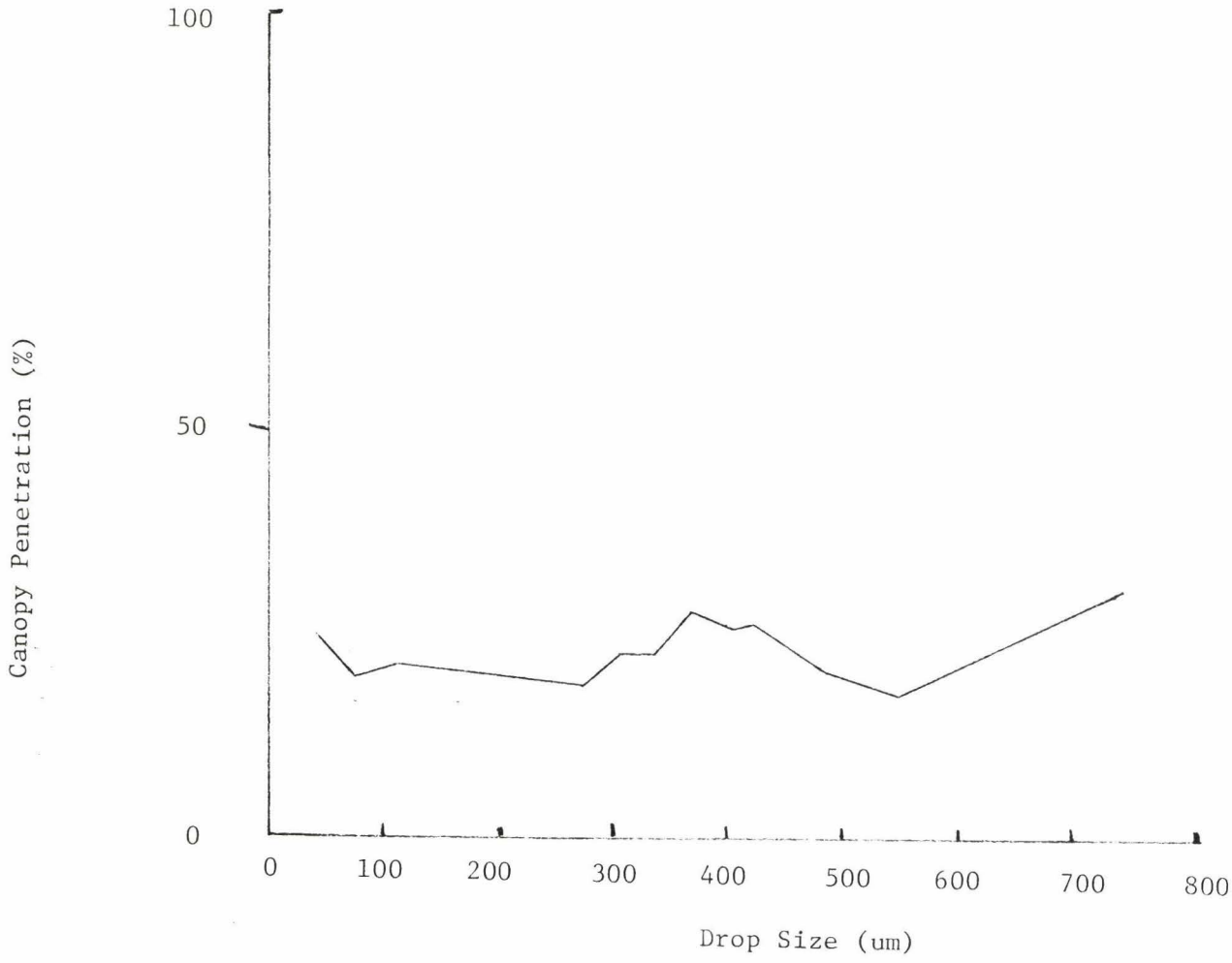


Figure 28. Subunit 6, Sevin®-4-oil canopy penetration by drop size. Canopy penetration ratio drops recovered under trees to drops recovered in open areas, plotted as a function of drops size, Santa Fe National Forest, 1977.

Two treated subunits (4 and 6) were monitored June 10 through June 16 by placing a line of air filter and Mylar fallout collectors downwind in the Rio de Las Vacas drainage. Meteorological data were collected at a site near the confluence of Trail Creek and Rio de Las Vacas. An aircraft was used to collect additional meteorological data.

The results of the study show that the insecticide was transported for a distance of several miles. The distance and quantity of the material transported in the air was dependent on the orography of the area treated and the air drainage pattern (downslope). Specific study results can be obtained by referring to the paper mentioned in footnote 2.

12. Weather Forecasting and Meteorological Monitoring

The responsibilities of the meteorologist were to: 1) obtain and interpret daily synoptic and local weather forecasts; 2) take meteorological measurements on treatment subunits to insure that spraying was done only when temperatures were below 70° F, winds did not exceed 6 miles per hour, or thermal lifting of the spray was not occurring; 3) advise project personnel on application strategy related to meteorological conditions.

a. Synoptic Forecasting

George Gregg, meteorologist in charge of the Albuquerque Weather Forecast Office, National Weather Service (NWS) provided a daily synoptic forecast. NWS personnel telephoned daily forecasts at 1800 and 0400 hours to the Meteorology Chief in Cuba, New Mexico. These forecasts were used to determine if spraying could be done based on temperatures, wind speed, and precipitation projections.

Weather was favorable for spraying from June 10 through 19. Winds aloft were light, morning temperatures were moderate, and only occasional scattered thunderstorms occurred in the afternoon hours. Figures 29 through 36 portray the general weather patterns from June 16 through 19. Maps are not provided for June 10 through 12, but the weather patterns were similar to June 13 (Fig. 30).

b. Meteorological Data from Treatment Subunits

A meteorological site was selected for each treatment subunit on the day before spraying. Criteria used for selection of meteorological site were an easterly face, near the upper one-third of the subunit (but at least 200 feet below the ridgetop), an opening of at least 150 feet in diameter, representative timber type, and road access. It was not always possible to meet all of these criteria, but each site was considered adequate for collecting the needed information.

U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration • Environmental Data Service

daily weather maps

Weekly Series JUNE 6-12, 1977

The charts in this publication are the principal charts of the former Weather Bureau publication, "Daily Weather Map." They are the Surface Weather Map, the 500-Millibar Height Contours chart, the Highest and Lowest Temperatures chart, and the Precipitation Areas and Amounts chart. All charts for each day are arranged on a single page. They are copied from operational weather maps prepared by the National Meteorological Center, National Weather Service. The symbols on the Surface Weather Map and the 500-Millibar Height Contours chart are standard international symbols. Official copies of an explanatory sheet are available from National Oceanic and Atmospheric Administration, Central Logistics Supply Center, 619 Hardesty Street, Kansas City, MO 64124. Sales copies may be ordered from Public Documents Department, U.S. Government Printing Office, Washington, D.C. 20402, single copy 40 cents. Orders of 100 copies or more mailed to one address are discounted at 25 percent. Make checks payable to "Superintendent of Documents."

The Surface Weather Map shows station data and the analysis for 7:00 a.m., EST. Tracks of well-defined low pressure areas are indicated by chain of arrows; locations of these centers at 6, 12, and 18 hours preceding map time are indicated by small white crosses in black squares. Areas of precipitation are indicated by shading. The weather reports printed here are only a fraction of those on which the analyses are based. Occasional apparent discrepancies between the printed station data and the analyses result from absence of station reports not included here because of lack of space.

The 500-Millibar Height Contours chart shows height contours and isotherms of the 500-millibar surface at 7:00 a.m., EST. Height contours are shown as continuous lines labeled in feet above sea level. Isotherms are shown as dashed lines labeled in degrees Celsius. Arrows show the wind direction and speed at the 500-millibar level.

The Highest and Lowest Temperatures chart shows the maximum and minimum values for the 24-hour period ending at 1:00 a.m., EST. The names of the reporting points are shown on the Surface Weather Map. The maximum temperature is plotted above the station location, and the minimum temperature is plotted below.

The Precipitation Areas and Amounts chart shows areas (shaded) that had precipitation during the 24 hours ending at 1:00 a.m., EST, with amounts to the nearest hundredth of an inch. Incomplete totals are underlined. "T" indicates a trace of precipitation. Dashed lines, in season, show the depth of snow on the ground in inches at 7:00 a.m., EST.

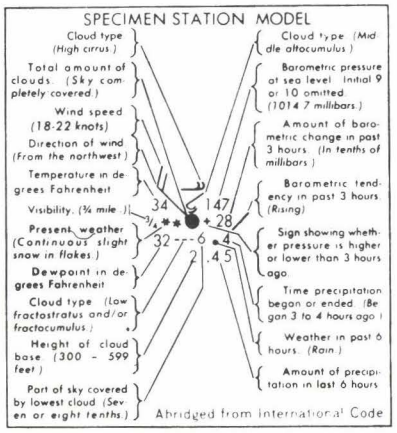

SPECIMEN STATION MODEL
Cloud type (High cirrus.)
Total amount of clouds. (Sky completely covered.)
Wind speed (18-22 knots)
Direction of wind (From the northwest)
Temperature in degrees Fahrenheit
Visibility. (¾ mile.)
Present weather (Continuous slight snow in flakes.)
Dewpoint in degrees Fahrenheit
Cloud type (Low fractostratus and/or fractocumulus.)
Height of cloud base (300 - 599 feet.)
Part of sky covered by lowest cloud (Seven or eight tenths.)
Cloud type (Middle altocumulus.)
Barometric pressure at sea level. Initial 9 or 10 omitted. (1014.7 millibars.)
Amount of barometric change in past 3 hours. (In tenths of millibars.)
Barometric tendency in past 3 hours. (Rising)
Sign showing whether pressure is higher or lower than 3 hours ago.
Time precipitation began or ended. (Began 3 to 4 hours ago.)
Weather in past 6 hours. (Rain.)
Amount of precipitation in last 6 hours
34
32
47
28
6
4
2
45
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Figure 29.--Information on daily weather maps.

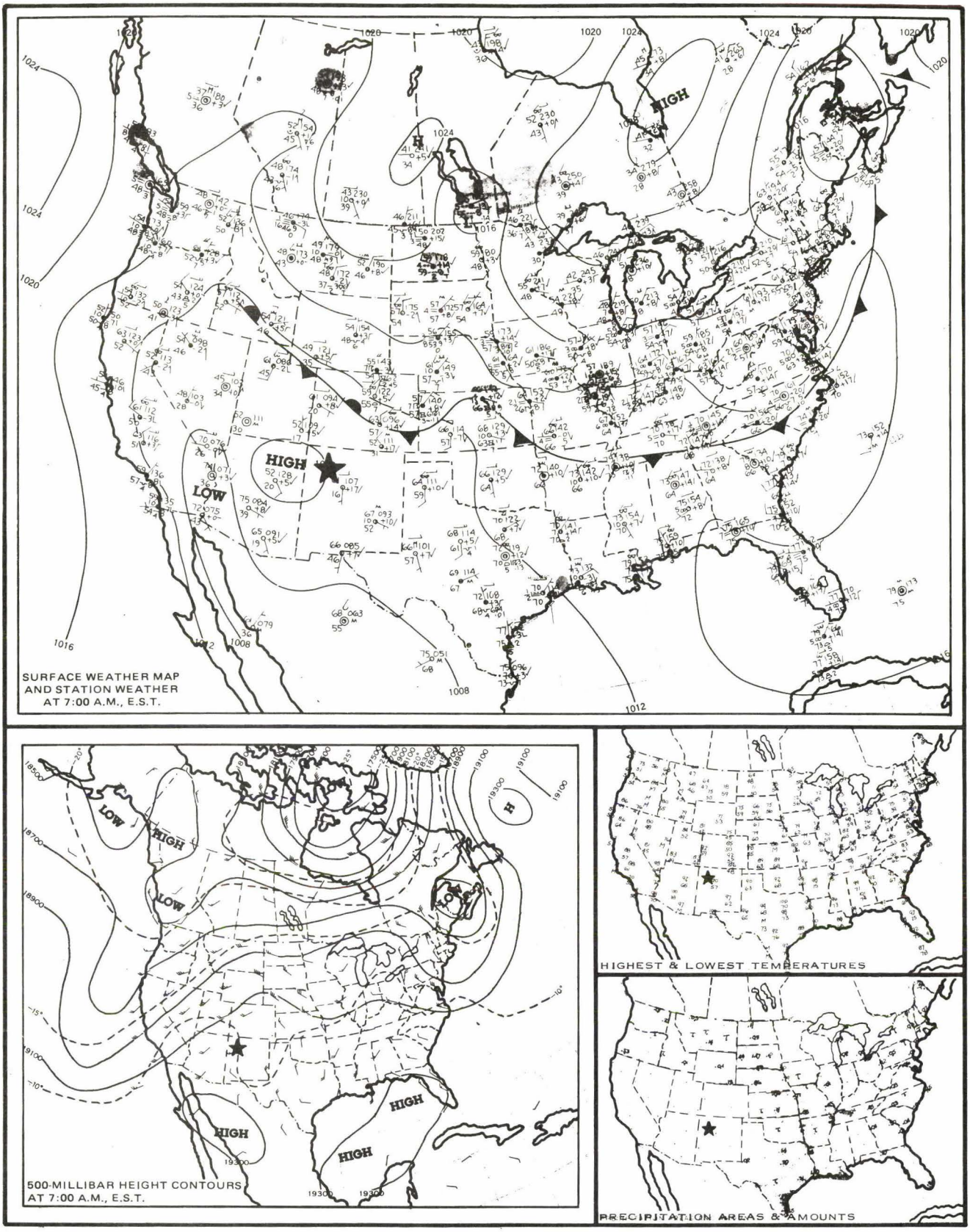


Figure 30.--Daily weather map for June 13, 1977.

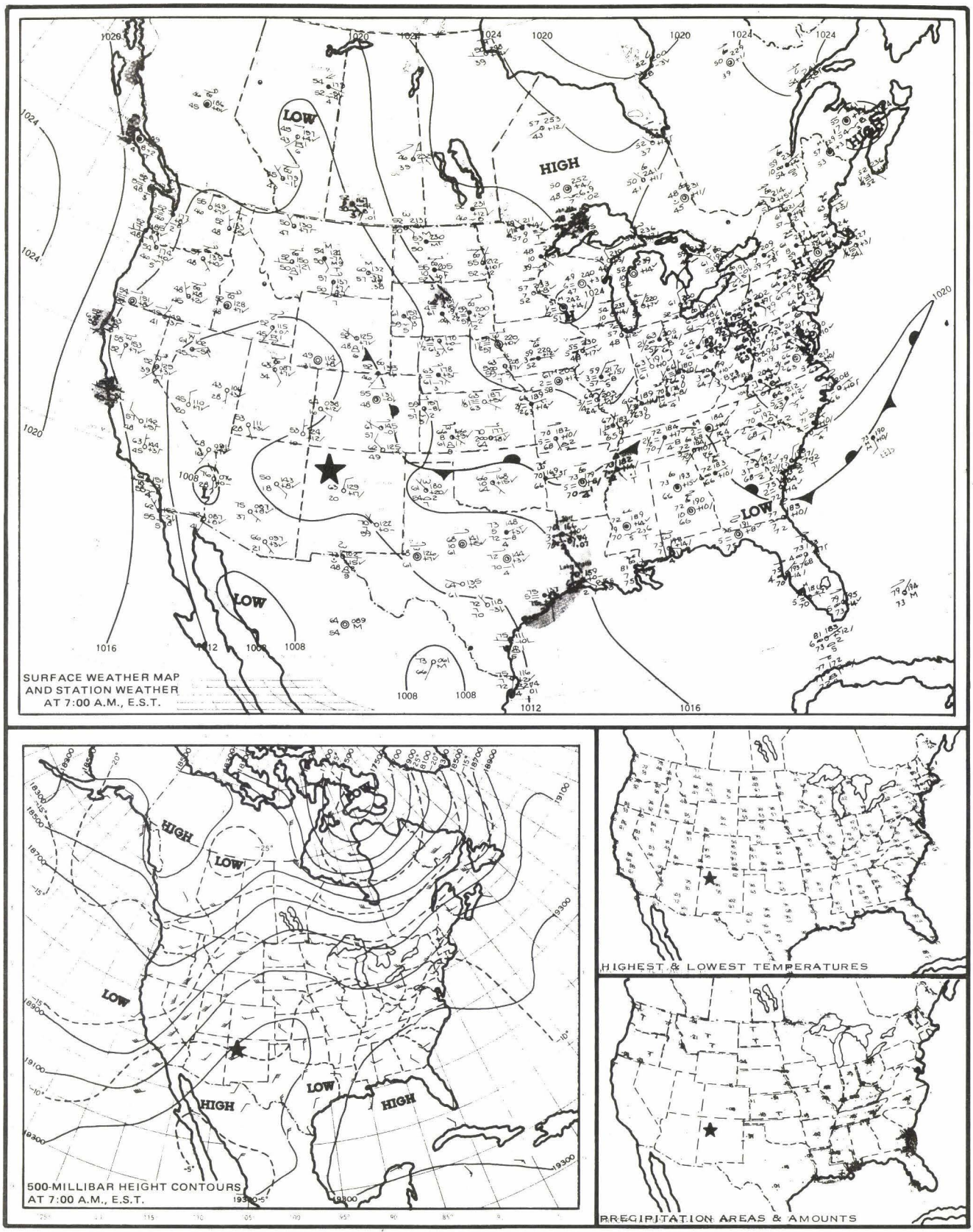


Figure 31.--Daily weather map for June 14, 1977.

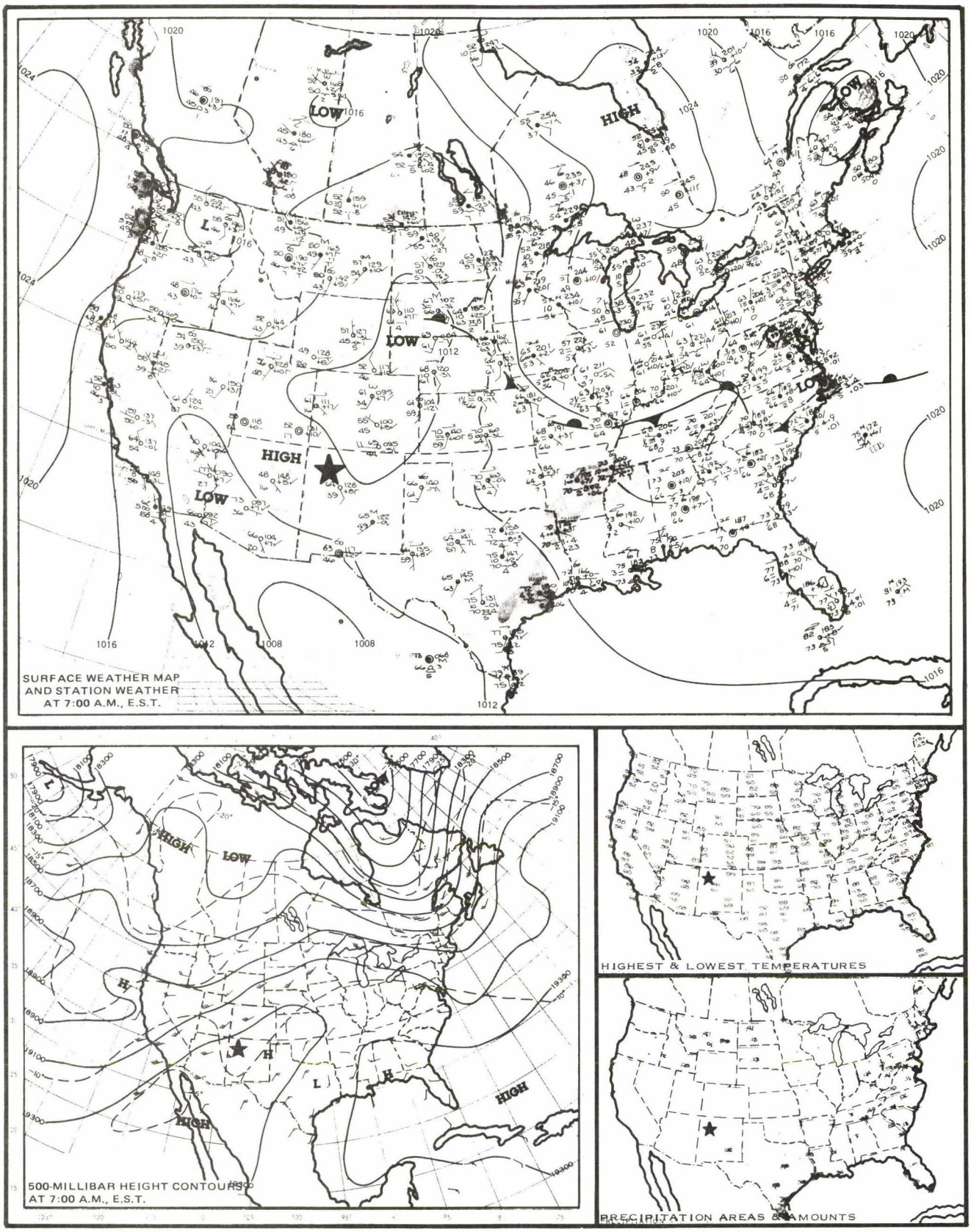


Figure 32.--Daily weather map for June 15, 1977.

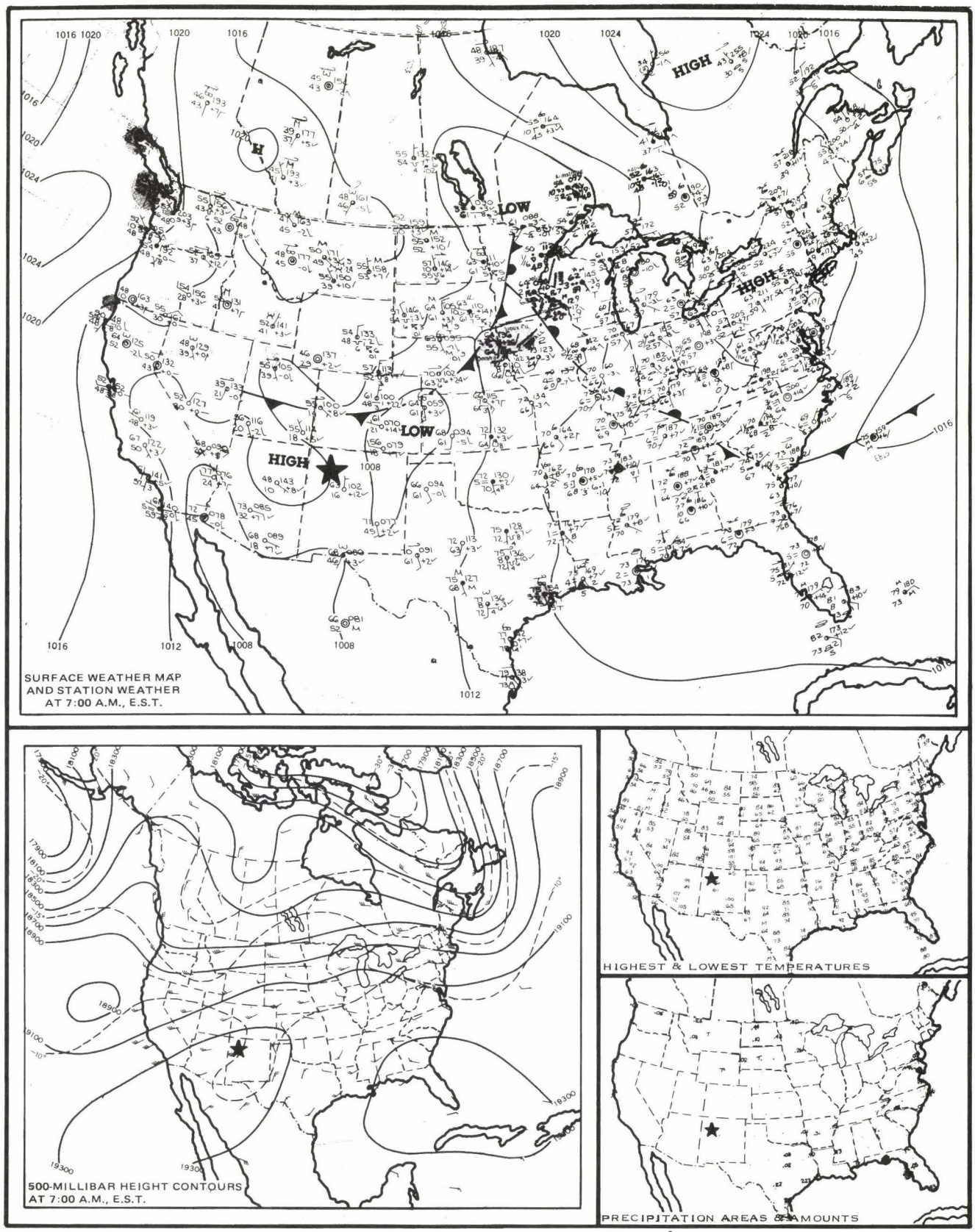


Figure 33.--Daily weather map for June 16, 1977.

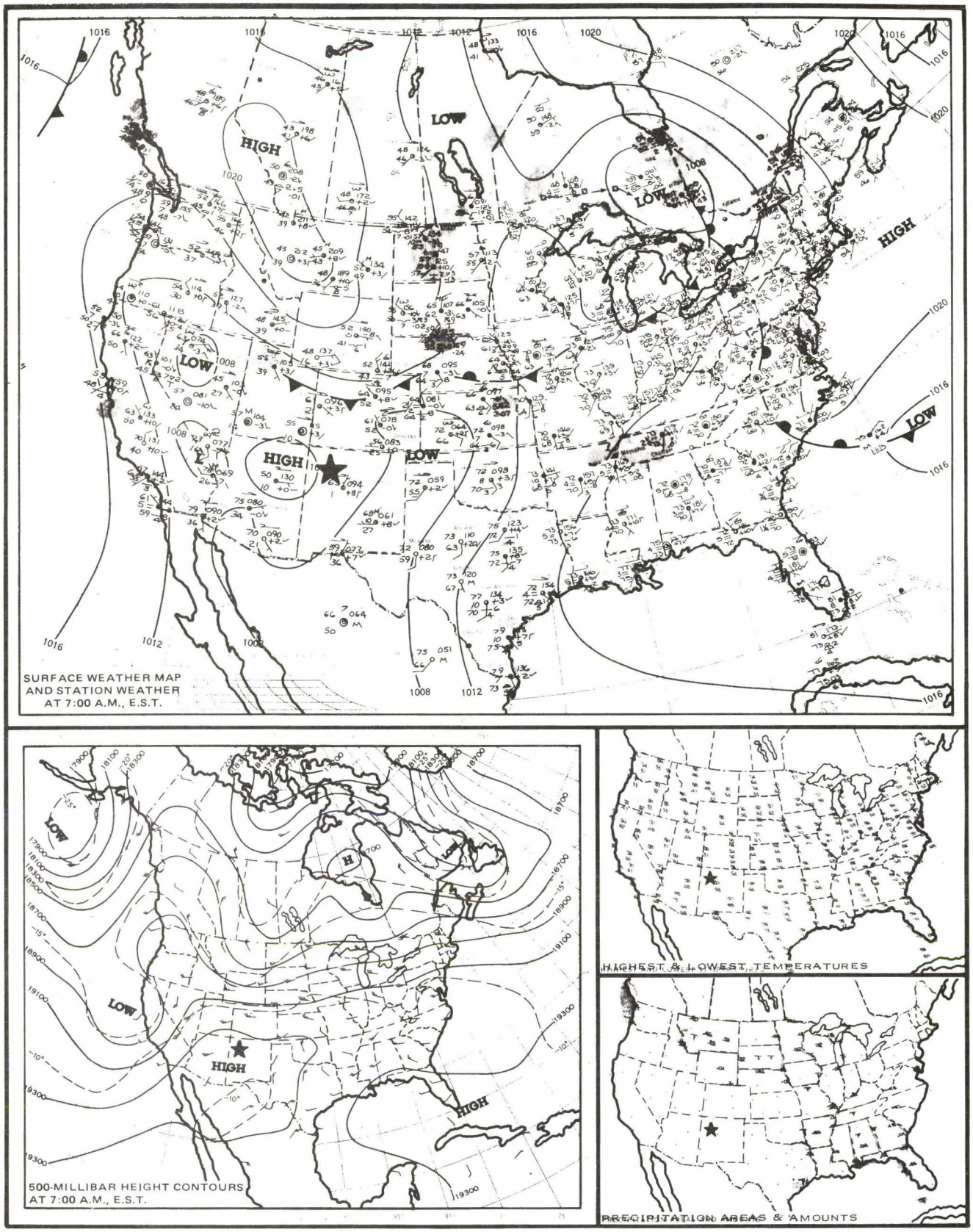


Figure 34.--Daily weather map for June 17, 1977

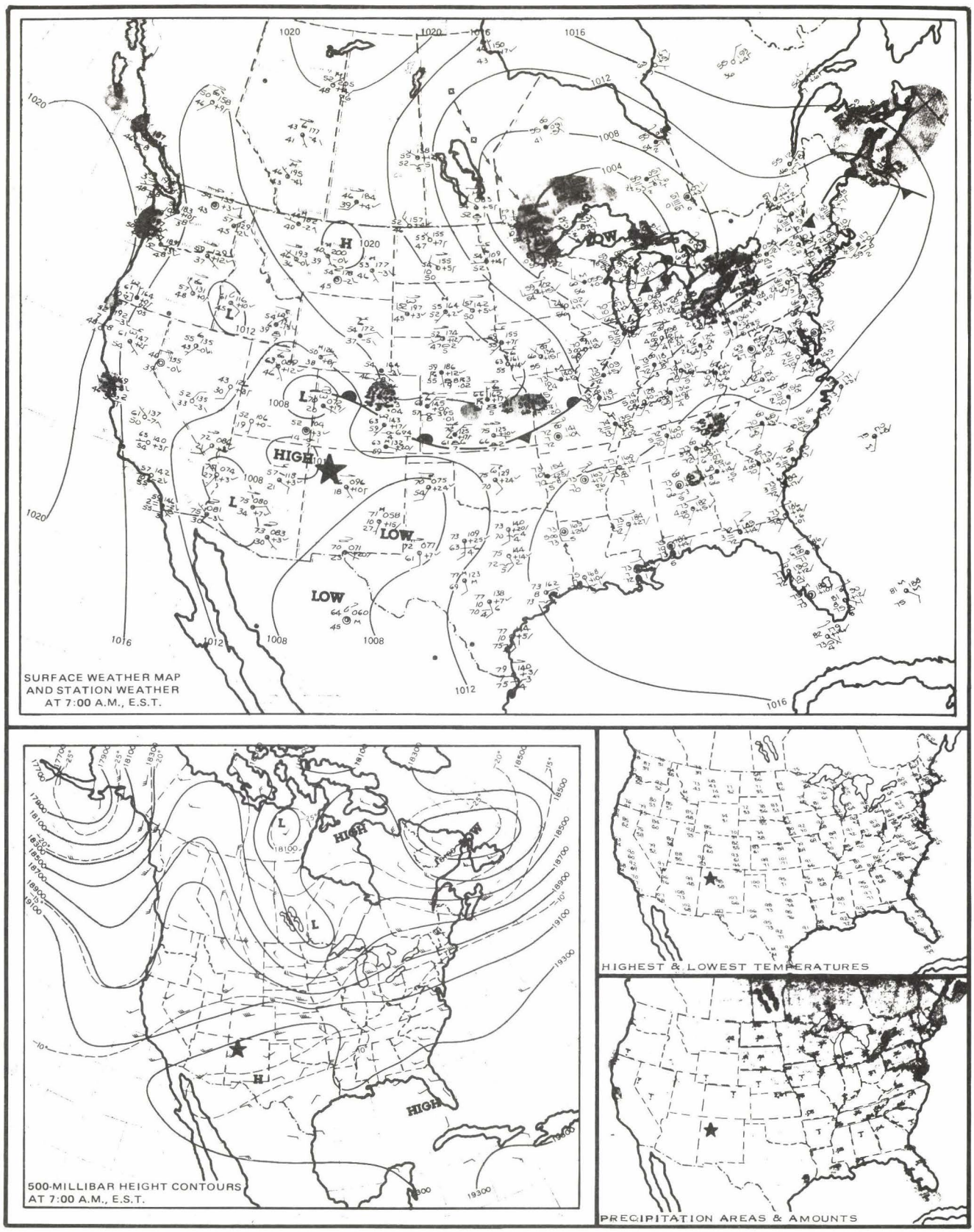


Figure 35.--Daily weather map for June 18, 1977.

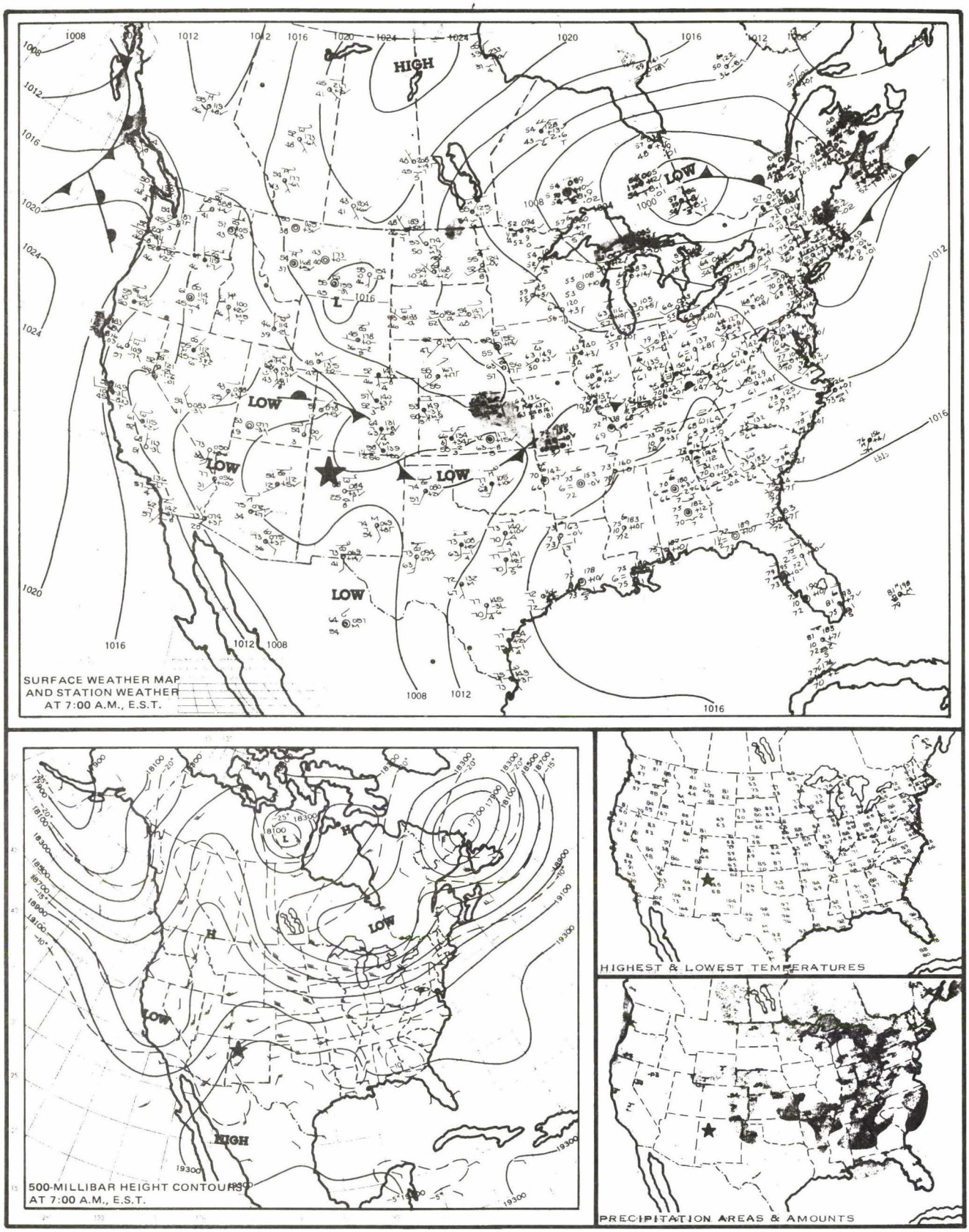


Figure 36.--Daily weather map for June 19, 1977.

Equipment used at the meteorological site were:

(1) Portable weather station with sensors to measure wind speed, wind direction, temperature, and relative humidity. Sensors were located 5 feet above ground level. Data were recorded continuously on a paper tape.

(2) A balloon supported hot film anemometer at 50 feet above the tree canopy, with a direct reading dial, was used to measure wind speed.

(3) Smoke grenades were used for visual interpretation of local air movements.

(4) Helium-filled, free weather balloons were used to observe turbulence and wind direction aloft.

A Santa Fe National Forest employee at the Red Top Fire Lookout (Fig. 2) provided wind speed, wind direction, and dry and wet bulb temperatures at 30-minute intervals when radio communications were possible. These measurements were used as a comparison with the meteorological site measurements.

Meteorological conditions were radioed to the project director at heliports at 30-minute intervals during spraying operations. Reports were made at more frequent intervals when conditions approached levels where spraying would be terminated. A warning was issued by the Meteorology Chief when it became apparent that favorable spraying conditions would be lost and spraying was stopped. Refer to Table 9 for spraying times from June 10 though 19.

Local weather conditions were ideal for spraying. Wind speed and temperature data for application done during morning hours are shown in Table 10.

Evening spraying was attempted June 16. Wind and temperature conditions reached what appeared to be satisfactory levels at 1950 hours and spraying was initiated. However, aerial observers noted that the spray was lifting and spraying was stopped.

13. Orientation of Spray Aircraft

Aerial observers flying in two Hiller 12E helicopters were used to direct spray aircraft. Their job was to insure that: 1) helicopters did not spray outside of subunit boundaries, which were located on well-defined geographical features, roads, ridges, etc.; 2) no spraying was done in Travel and Water Influence Zones; 3) spraying was not done any closer than 1 mile from the San Pedro Parks Wilderness; 4) overlap of spray swaths was adequate; and 5) safety procedures were observed.

Table 9.--Period of spraying on the western spruce budworm suppression and evaluation project, Santa Fe National Forest, 1977.

Date	Subunit	Spraying time		Length of Spraying	
		Start	Stop	Hours	Minutes
6/10	6	0545	1010	4	25
6/11	5	0545	1040	4	55
	6	1019	1040		21
6/12	2	0547	0915	3	28
6/13	2	0521	0900	3	39
	1	0842	0920		38
6/14	1	0523	1027	5	04
6/15	4	0527	0830	3	03
	6	1950	2125	1	35
6/16	4	0537	0835	2	58
	3	0818	0918	1	00
6/17	3	0543	1000	4	17
6/18	3	0518	0745	2	27
	6	0750	0925	1	35
6/19	6	0523	0714	1	51

Table 10.--Wind speed and temperature data for spraying done during morning hours, Santa Fe National Forest, 1977.

Date	Subunit	Hour	Temperature (°F)	Wind speed (m.p.h.)		
				Average*	Minimum	Maximum
6/10	6	0615	43	1.0	--	--
		0630	43	1.0	--	--
		0645	44	1.0	--	--
		0700	44	1.0	--	--
		0715	48	1.5	--	--
		0730	50	1.3	--	--
		0745	54	1.5	--	--
		0800	58	0.8	--	--
		0815	61	2.0	--	--
		0830	62	2.0	--	--
		0845	62	2.0	--	--
		0900	63	2.1	--	--
		0915	64	2.1	--	--
		0930	65	2.1	--	--
		0945	65	3.0	--	--
		1000	68	2.0	--	--
6/11	5	0545	48	1.0	--	--
		0600	49	2.5	--	--
		0615	52	2.6	--	--
		0630	49	1.5	--	--
		0645	49	1.0	--	--
		0700	50	1.0	--	--
		0715	53	2.0	--	--
		0730	53	2.5	--	--
		0745	52	0.5	--	--
		0800	56	0.5	--	--
		0815	58	0.5	--	--
		0830	62	2.0	--	--
		0845	63	1.0	--	--
	6	0900	63	1.2	--	--
		0915	63	1.0	--	--
		0930	62	1.0	--	--
		0945	64	1.0	--	--
		1000	64	1.0	--	--
		1015	62	1.0	--	--
		1030	62	1.0	--	--

*Average wind speed data were collected only for 3 days. Minimum and maximum wind speed data were determined to be more useful and these measurements were collected for the remainder of the project.

Table 10.--Wind speed and temperature data for spraying done during morning hours, Santa Fe National Forest, 1977 (continued).

Date	Subunit	Hour	Temperature (°F)	Wind speed (m.p.h.)		
				Average*	Minimum	Maximum
6/12	2	0645	42	2.2	--	--
		0700	44	2.8	--	--
		0715	45	3.0	--	--
		0730	48	3.5	--	--
		0745	50	4.0	--	--
		0800	50	4.0	--	--
		0815	54	4.8	--	--
		0830	50	4.0	--	--
		0845	50	4.0	--	--
		0900	47	3.4	--	--
6/13	2	0615	48	--	1.0	2.0
		0630	50	--	2.0	3.0
		0645	52	--	3.0	5.0
		0700	55	--	1.0	5.1
		0715	57	--	2.0	4.0
		0730	60	--	1.0	3.0
		0745	60	--	1.5	3.0
		0800	61	--	2.0	3.5
		0815	64	--	1.0	3.0
		0830	68	--	1.0	5.0
		0845	69	--	3.0	5.0
		0900	70	--	2.0	5.0
		0915	70	--	3.0	6.0
6/14	1	0615	48	--	0.1	1.0
		0630	48	--	0.1	1.2
		0645	49	--	0.3	1.9
		0700	49	--	0.9	2.0
		0715	49	--	0.7	2.8
		0730	51	--	0.2	1.8
		0745	52	--	0.1	1.8
		0800	53	--	1.0	2.0
		0815	55	--	1.2	2.1
		0830	59	--	0.1	2.4
		0845	61	--	0.1	2.4
		0900	62	--	0.1	1.7
		0915	63	--	0.1	2.1
		0930	63	--	0.3	2.1
		0945	66	--	0.8	4.8
		1000	67	--	0.2	4.8
		1015	67	--	0.8	4.1
		1030	68	--	0.6	6.0
		1045	68	--	2.0	5.0

*Average wind speed data were collected only for 3 days. Minimum and maximum wind speed data were determined to be more useful and these measurements were collected for the remainder of the project.

Table 10.--Wind speed and temperature data for spraying done during morning hours, Santa Fe National Forest, 1977 (continued).

Date	Subunit	Hour	Temperature (°F)	Wind speed (m.p.h.)		
				Average*	Minimum	Maximum
6/15	4	0600	34	--	0.5	1.0
		0615	34	--	0.2	1.8
		0630	35	--	0.1	1.0
		0645	37	--	0.7	1.0
		0700	36	--	0.8	1.2
		0715	38	--	1.0	1.5
		0730	43	--	1.2	3.0
		0745	50	--	1.0	1.8
		0800	59	--	1.0	2.0
		0815	57	--	1.4	2.2
		0830	62	--	0.6	2.8
		0845	65	--	0.1	2.0
		0900	66	--	0.8	2.6
		0915	68	--	0.2	3.8
		0930	70	--	0.2	3.6
6/16	3	0600	32	--	--	1.5
		0615	32	--	--	1.5
		0630	31	--	--	1.5
		0645	32	--	--	1.8
		0700	32	--	--	2.0
		0715	32	--	--	--
		(Moved to new site)				
		0845	69	--	--	2.1
		0900	70	--	--	4.0
		0915	71	--	--	3.0
6/17	3	0815	58	--	0.1	1.0
		0830	60	--	0.2	1.0
		0845	65	--	0.8	2.0
		0900	65	--	0.1	3.0
		0915	69	--	0.1	3.4
		0930	71	--	0.5	4.7
		0945	72	--	0.4	3.2
6/18	3	0630	41	--	0.2	4.0
		0645	41	--	0.1	3.0
		0700	43	--	1.2	2.9
		0715	45	--	1.1	2.6
		0730	46	--	1.0	2.2

*Average wind speed data were collected only for 3 days. Minimum and maximum wind speed data were determined to be more useful and these measurements were collected for the remainder of the project.

Table 10.--Wind speed and temperature data for spraying done during morning hours, Santa Fe National Forest, 1977 (continued).

Date	Subunit	Hour	Temperature (°F)	Wind speed (m.p.h.)		
				Average*	Minimum	Maximum
6/18	3	0745	54	--	0.4	2.7
		0800	56	--	0.3	1.0
		0815	62	--	1.0	2.6
		0830	66	--	0.2	3.0
		0845	66	--	1.5	6.0
		0900	66	--	0.5	3.5
		0915	66	--	1.0	3.5
		0930	68	--	1.0	6.0
6/19	6	(Weather data were taken, but not recorded)				

*Average wind speed data were collected only for 3 days. Minimum and maximum wind speed data were determined to be more useful and these measurements were collected for the remainder of the project.

An observer was in the air at all times directing spraying helicopters. At the same time, the other observer was on the ground being briefed by the Project Personnel (Fig. 21). When a helicopter ran low on fuel, the other observer helicopter would go into the air to direct spraying helicopters.

Aerial observers did an excellent job, with the exception of one accidental spraying of a stream. An observer failed to tell a spray helicopter to cease spraying, and a portion of San Pablo Creek subunits was sprayed. Refer to the Environmental Monitoring section for the effects of this accident.

Figure 37.--Project personnel discussing spraying progress and strategies during spraying operations, Santa Fe National Forest, 1977.

III. ENTOMOLOGICAL PHASES

A. Objectives

The entomological phases of the 1977 western spruce budworm project had the following objectives:

1. Timing Insecticide Application

Determine budworm larval development so that Sevin®-4-oil could be applied when 20 percent of the budworm population were fifth and sixth instar larvae.

2. Immediate Project Effectiveness

Evaluate immediate budworm population reduction from Sevin®-4-oil applied against an increasing budworm population in the release phase of an infestation by measuring population changes on Douglas-fir during the 1976-7 generation.

3. Long-term Project Effectiveness

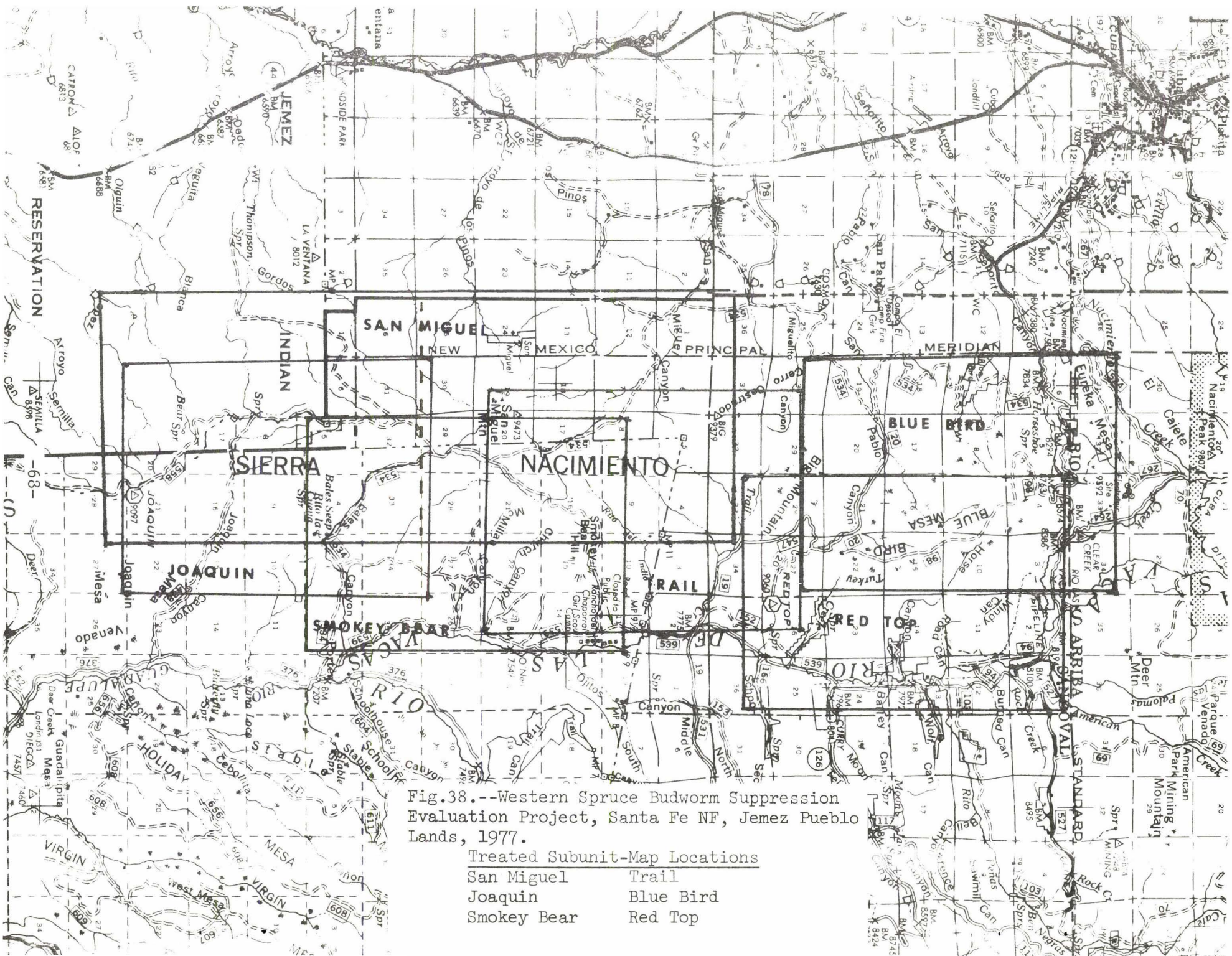
Determine long-term budworm population reduction from a Sevin®-4-oil application for at least two additional generations (1977-8 and 1978-9).

B. Methods

1. Sampling Locations

Each subunit was established on the basis of elevation, aspect and infested host timber type. Budworm populations were assumed to be at similar densities in all subunits, and it also was assumed that larval development would be uniform in each subunit. For the sprayed subunits, an additional criterion of minimal area treatable per day (about 6,000 acres) was used. This helped insure that the insecticide was applied at the optimal time for maximum population reduction.

Twenty-five sampling plots were distributed as uniformly as possible throughout each subunit along roads and trails. The plot selection, establishment, sampling, and foliage examination procedures were the same for sprayed and unsprayed subunits. Each plot was assigned a different number to identify where each sample was taken. All budworm population samples per plot were taken from trees located within a 1-acre area. Identifying plot numbers and their locations for each subunit are shown in Figures 38 to 53.


SAN MIGUEL
SIERRA
NACIMIENTO
JOAQUIN
SMOKEY BEAR
RAIL
BLUE BIRD
RED TOP
INDIAN
RESERVATION
NEW MEXICO PRINCIPAL MERIDIAN
JEMEZ
LA VENTANA
Arroyo Semilla
Joaquin Mesa
Deer Creek
Guadalupita
HOLIDAY
VIRGIN
West Mesa
Rio Puerco de Jemez
Rio Arriba
Rio Vacas
Rio Guadalupe
Eureka Mesa
Blue Bird Mesa
Red Top Mtn
Deer Mtn
Mount Stanley
Mount Nacimiento
Parque Venado
American Park Mining
Mountain
Cuba
Placita
Pipeline
Stable
Schoolhouse Canyon
Middle Canyon
North Sec
South
Trail
Rock Creek
Clear Creek
Horse Canyon
Turkey Canyon
Windy Canyon
Buried Canyon
Bailey Canyon
Wolf Canyon
Curry Canyon
Road Canyon
Miguelito Canyon
Castrado Canyon
Bales Canyon
Bales Seep
Rito la Cueva
Orejon Creek
Smokey Bear Hill
Closed to Public
Chaparral Girl Scout Camp
Horseshoe Spr
Thompson Spr
Beur Spr
Ponds
Vegas
Pajarito Fire Dept
Pajarito Girls Camp
Nacimiento Peak
Sierra Mtn
Mesa Venado
Mesa Joaquin
Mesa Rio Puerco
Mesa Rio Arriba
Mesa Rio Vacas
Mesa Rio Guadalupe

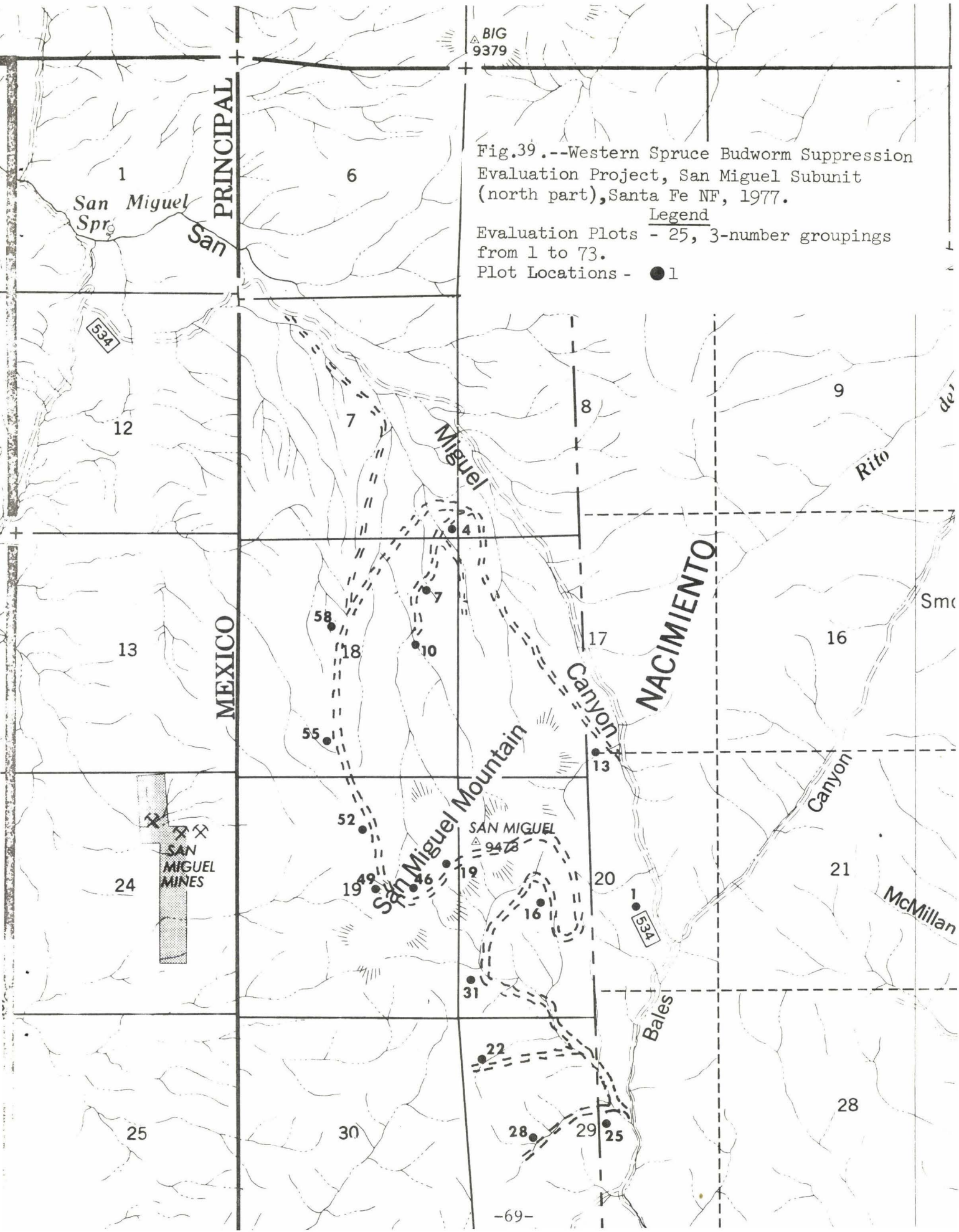


Fig.39.--Western Spruce Budworm Suppression Evaluation Project, San Miguel Subunit (north part), Santa Fe NF, 1977.

Legend

Evaluation Plots - 25, 3-number groupings from 1 to 73.

Plot Locations - ●1

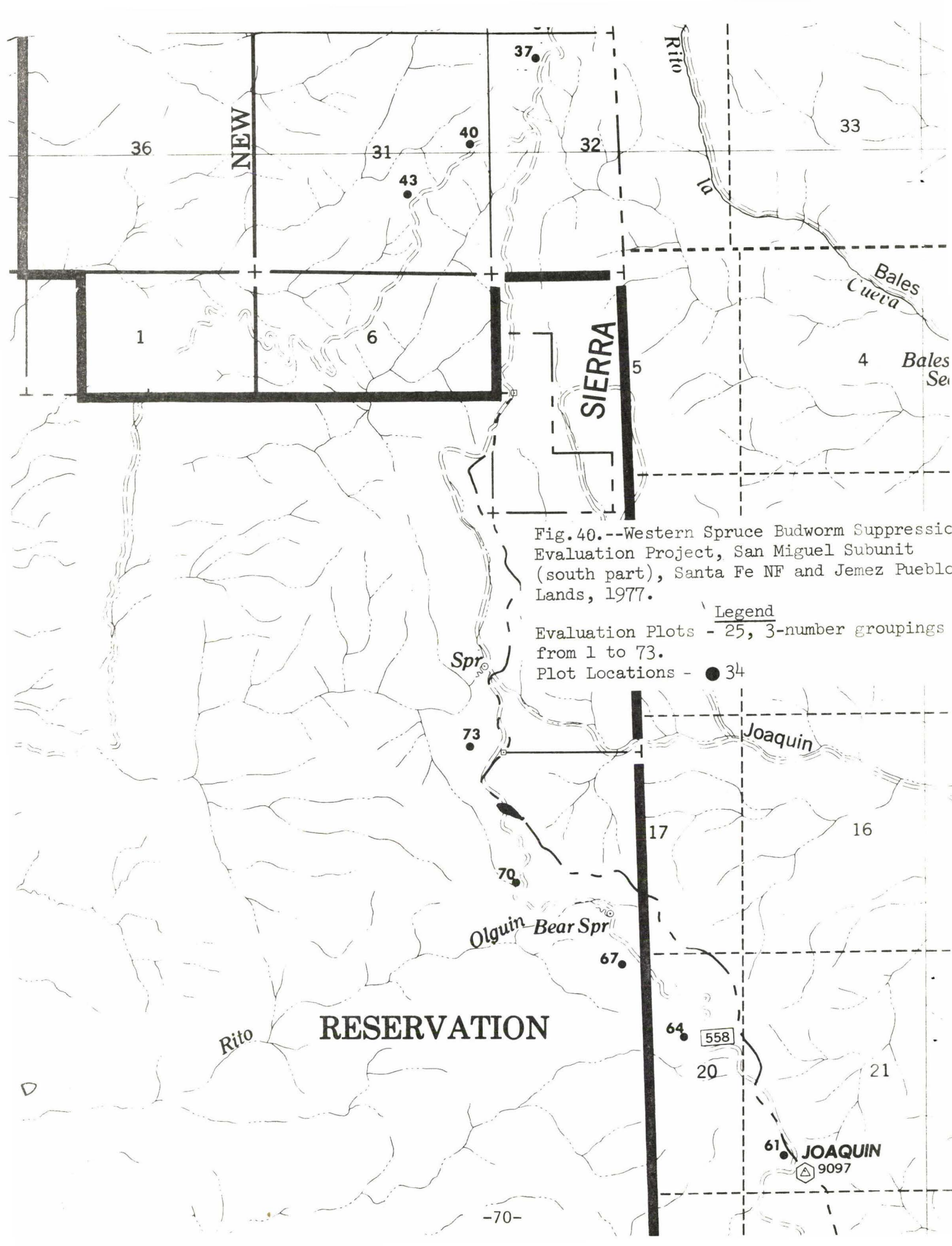


Fig.40.--Western Spruce Budworm Suppressio
Evaluation Project, San Miguel Subunit
(south part), Santa Fe NF and Jemez Pueblo
Lands, 1977.

Legend

Evaluation Plots - 25, 3-number groupings
from 1 to 73.
Plot Locations - ● 34

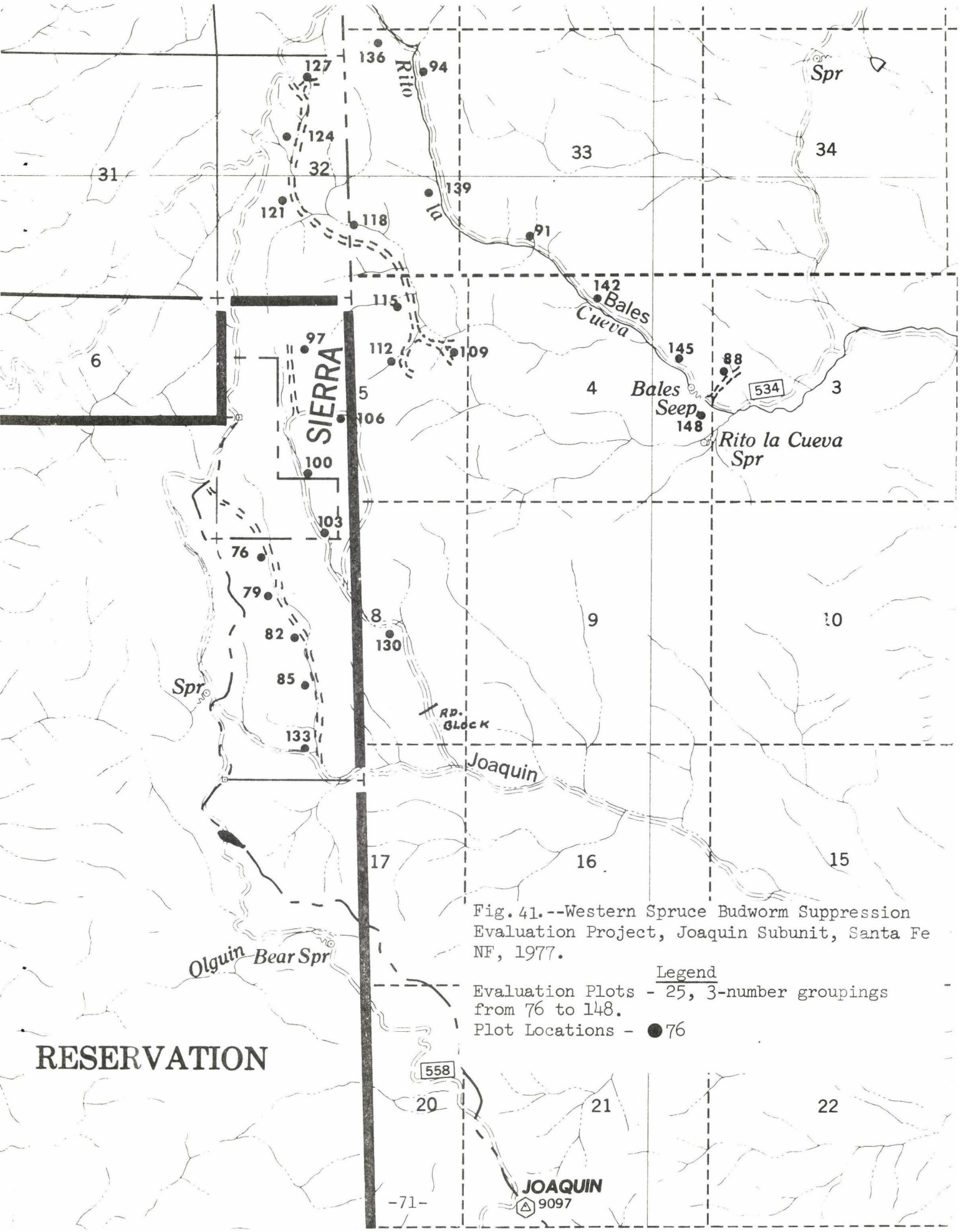


Fig. 41.--Western Spruce Budworm Suppression Evaluation Project, Joaquin Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots - 25, 3-number groupings from 76 to 148.

Plot Locations - ●76

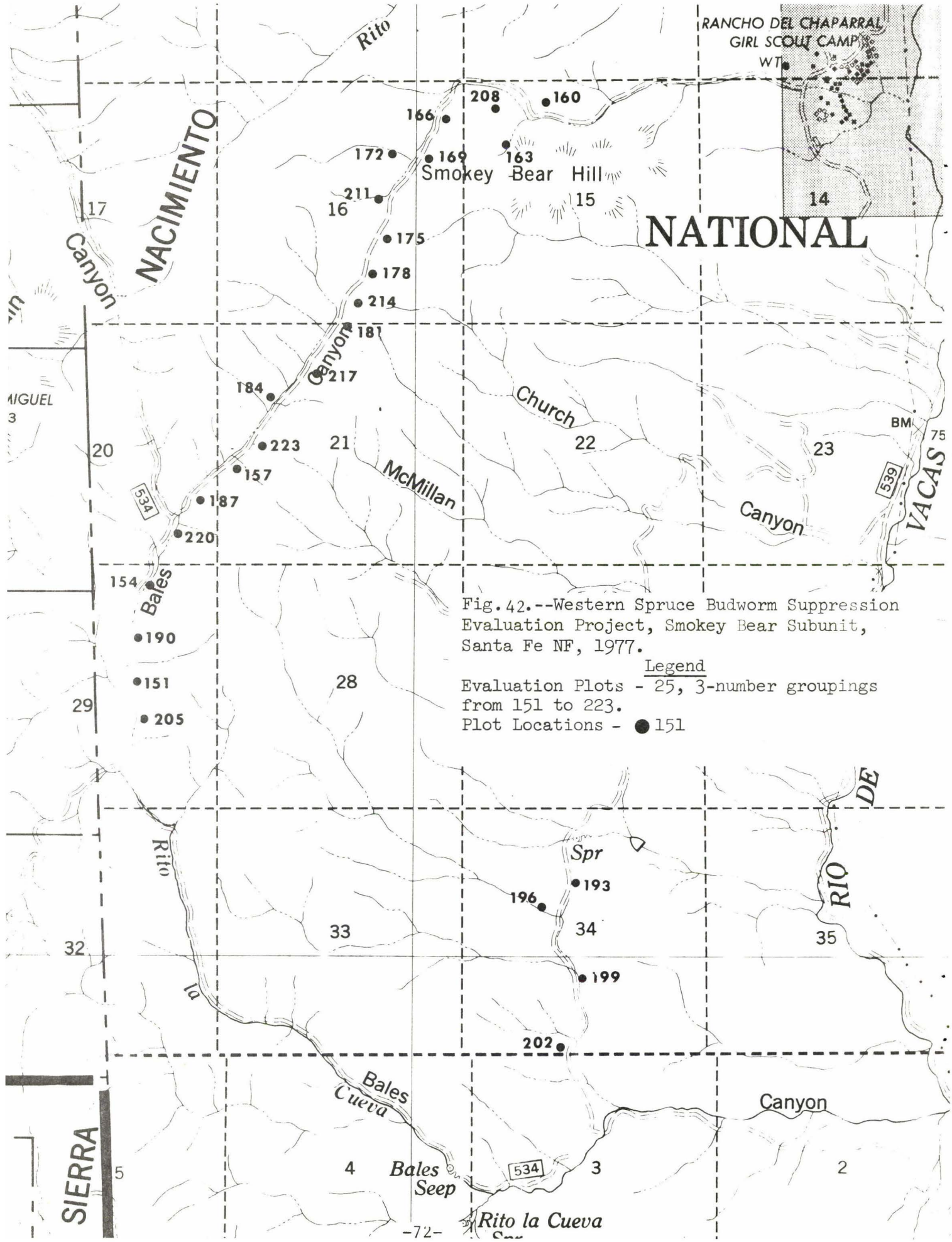


Fig. 42.--Western Spruce Budworm Suppression Evaluation Project, Smokey Bear Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots - 25, 3-number groupings from 151 to 223.

Plot Locations - ● 151

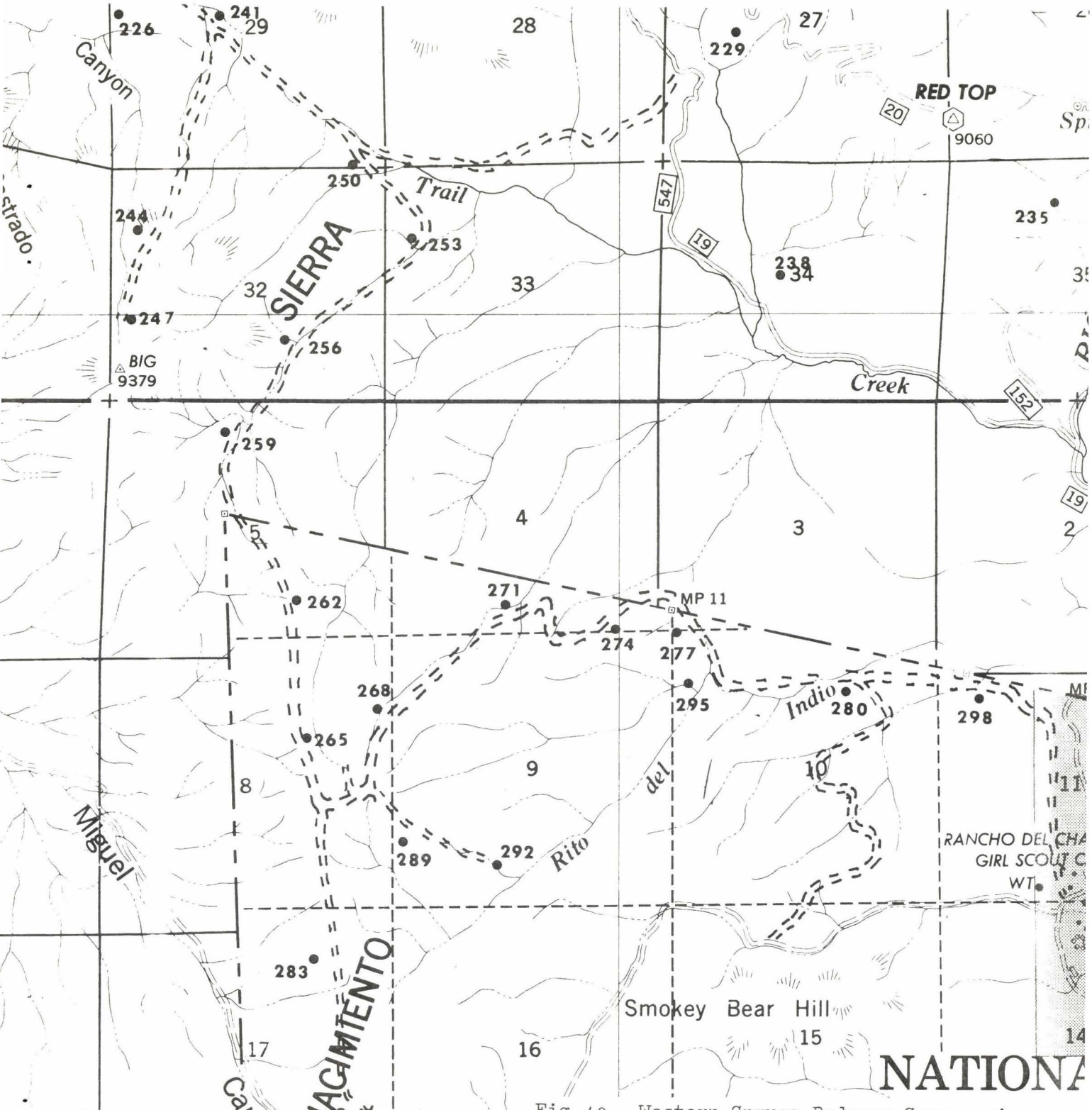


Fig. 43.--Western Spruce Budworm Suppression Evaluation Project, Trail Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots - 25, 3-number groupings from 226 to 298.

Plot Locations - ● 226

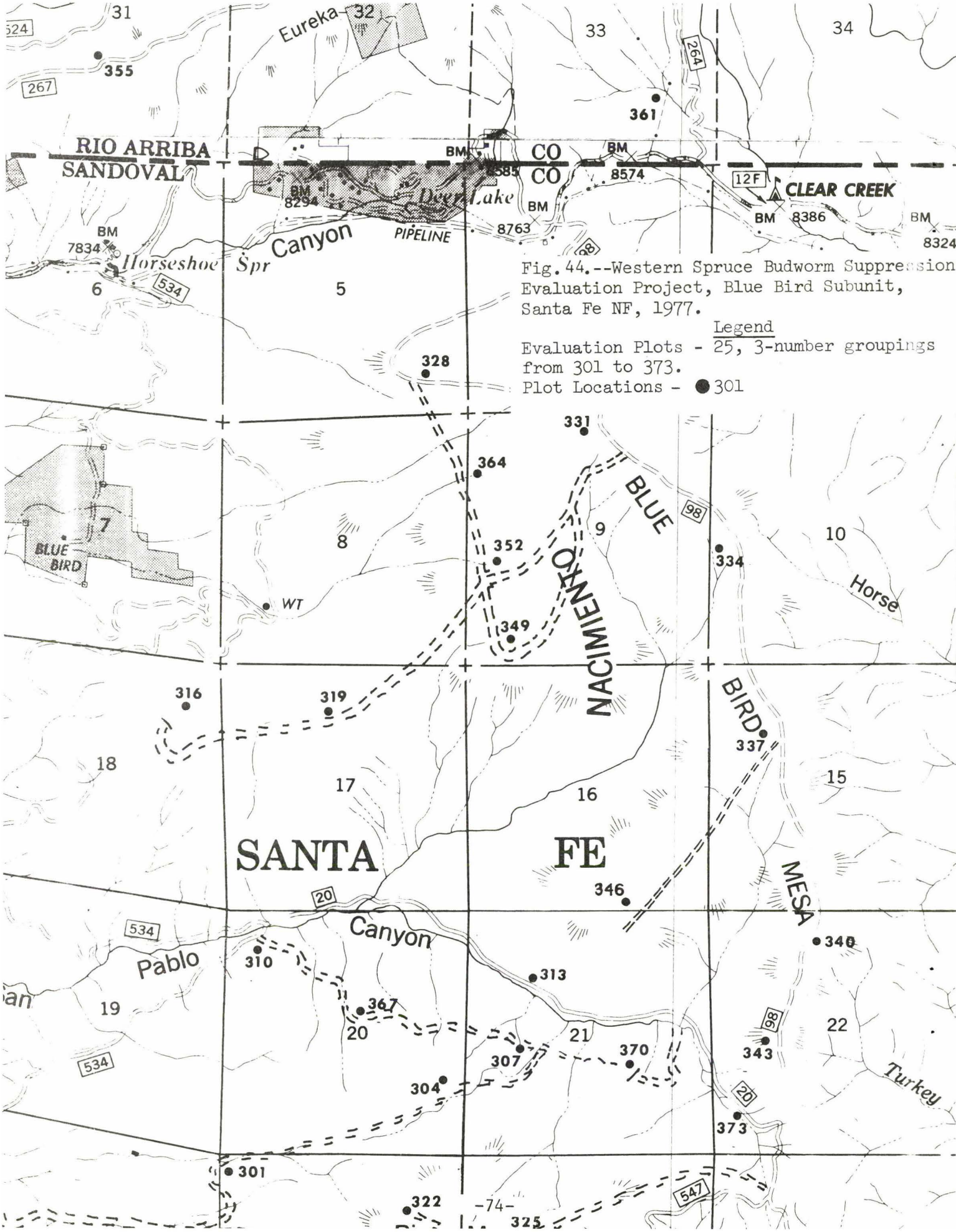


Fig. 44.--Western Spruce Budworm Suppression Evaluation Project, Blue Bird Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots - 25, 3-number groupings from 301 to 373.

Plot Locations - ● 301

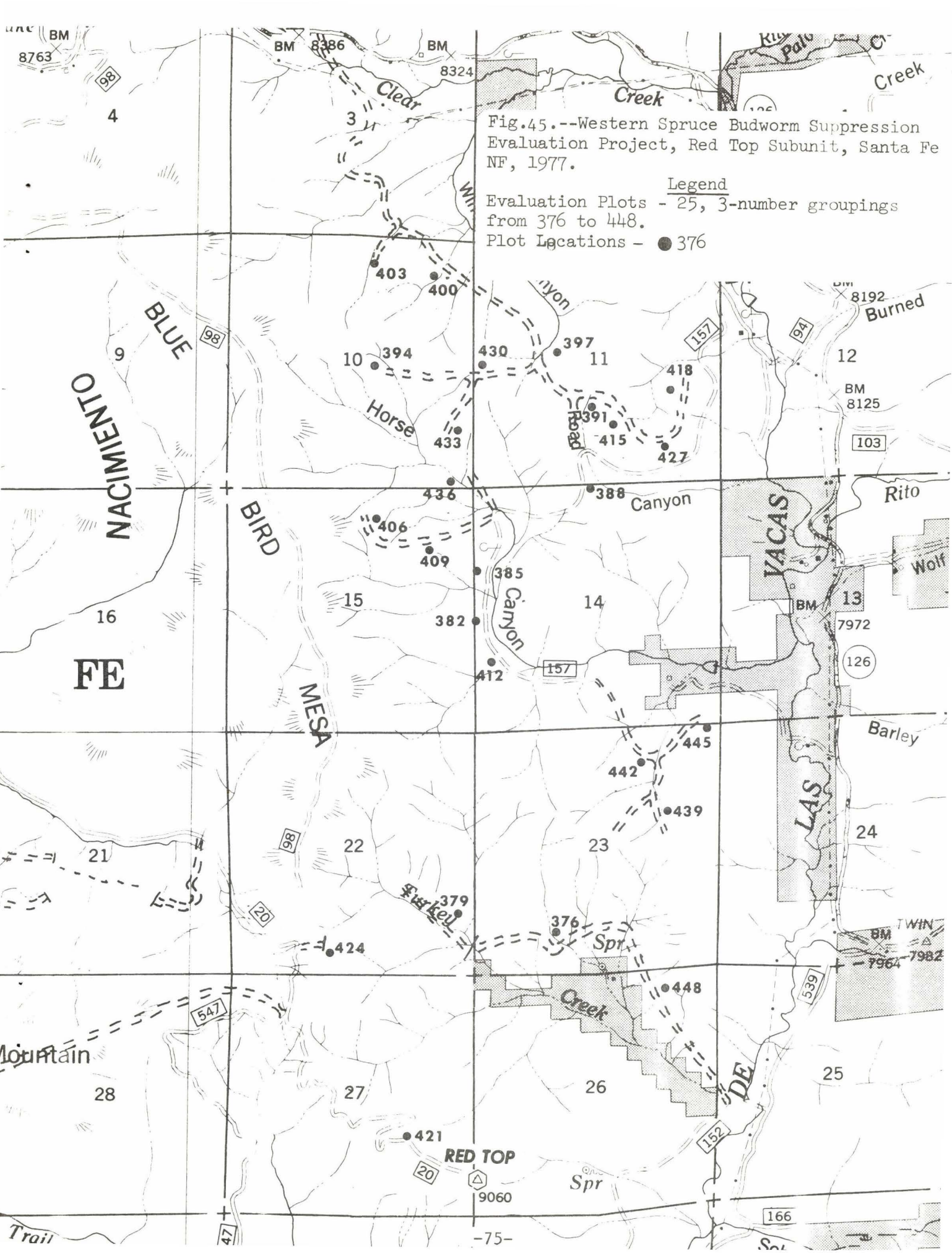


Fig.45.--Western Spruce Budworm Suppression Evaluation Project, Red Top Subunit, Santa Fe NF, 1977.

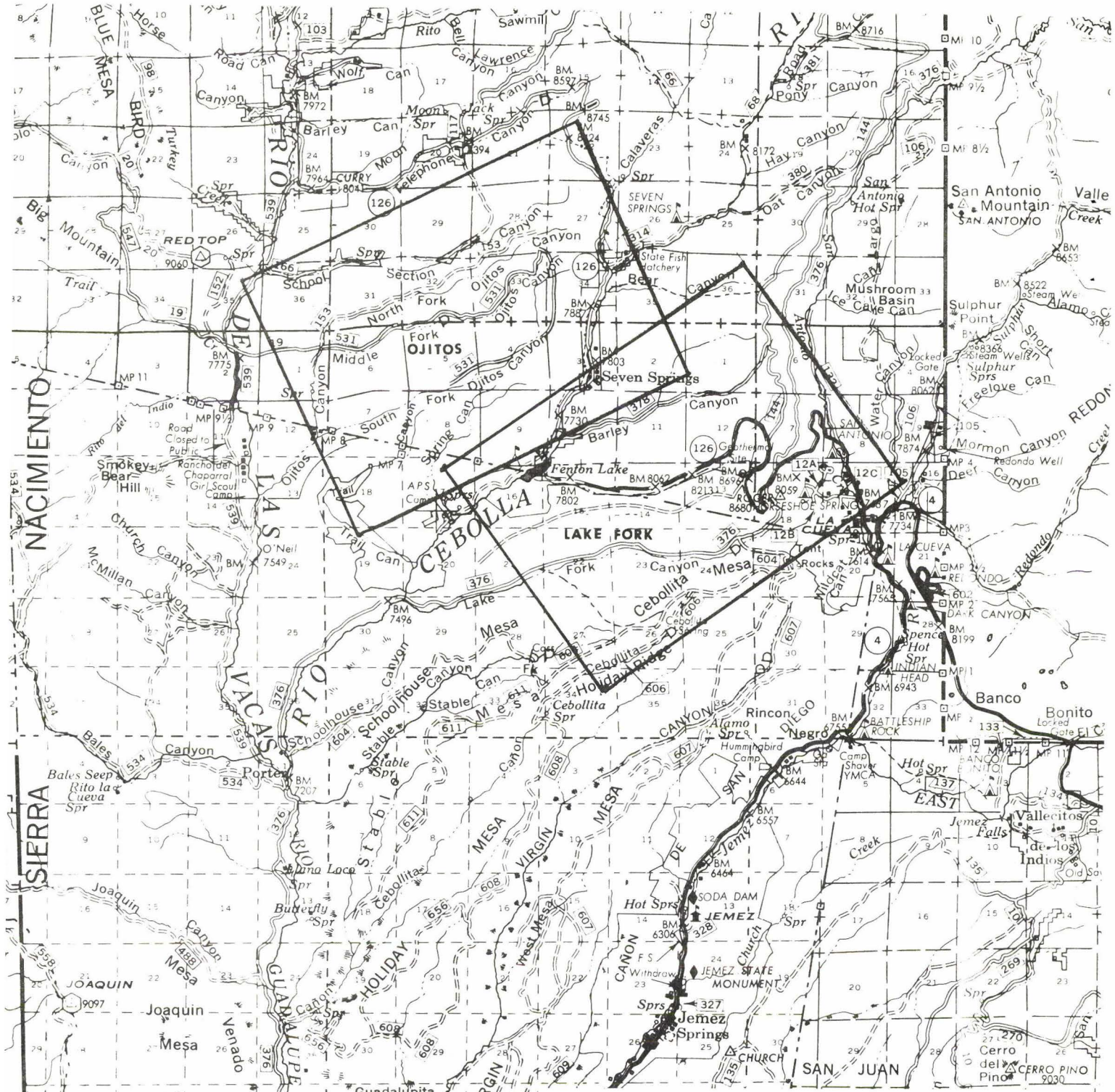


Fig.46.--Western Spruce Budworm Suppression Evaluation Project, Santa Fe NF, 1977.
Untreated Subunit-Map Locations

Ojitos
Lake Fork

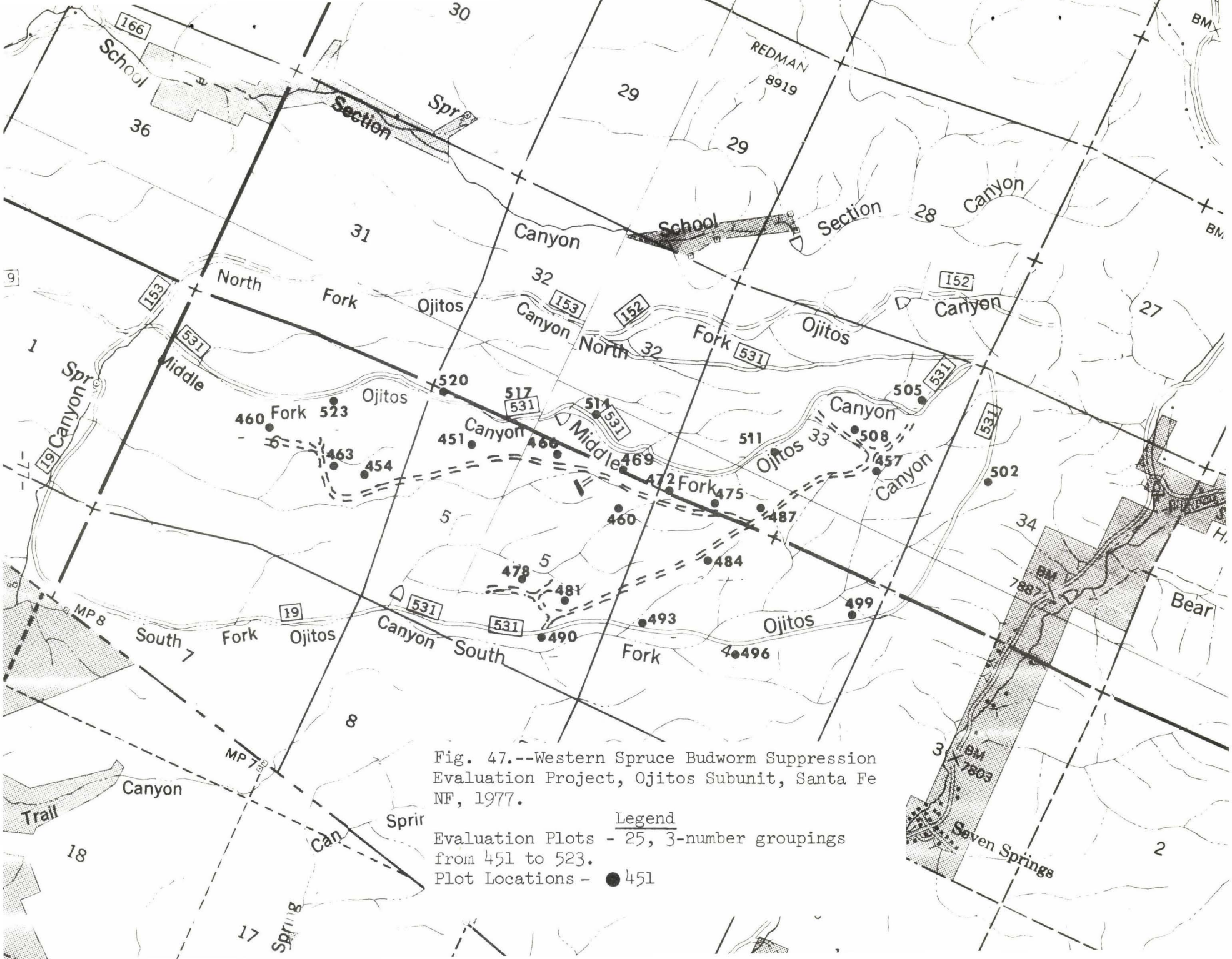


Fig. 47.--Western Spruce Budworm Suppression Evaluation Project, Ojitos Subunit, Santa Fe NF, 1977.

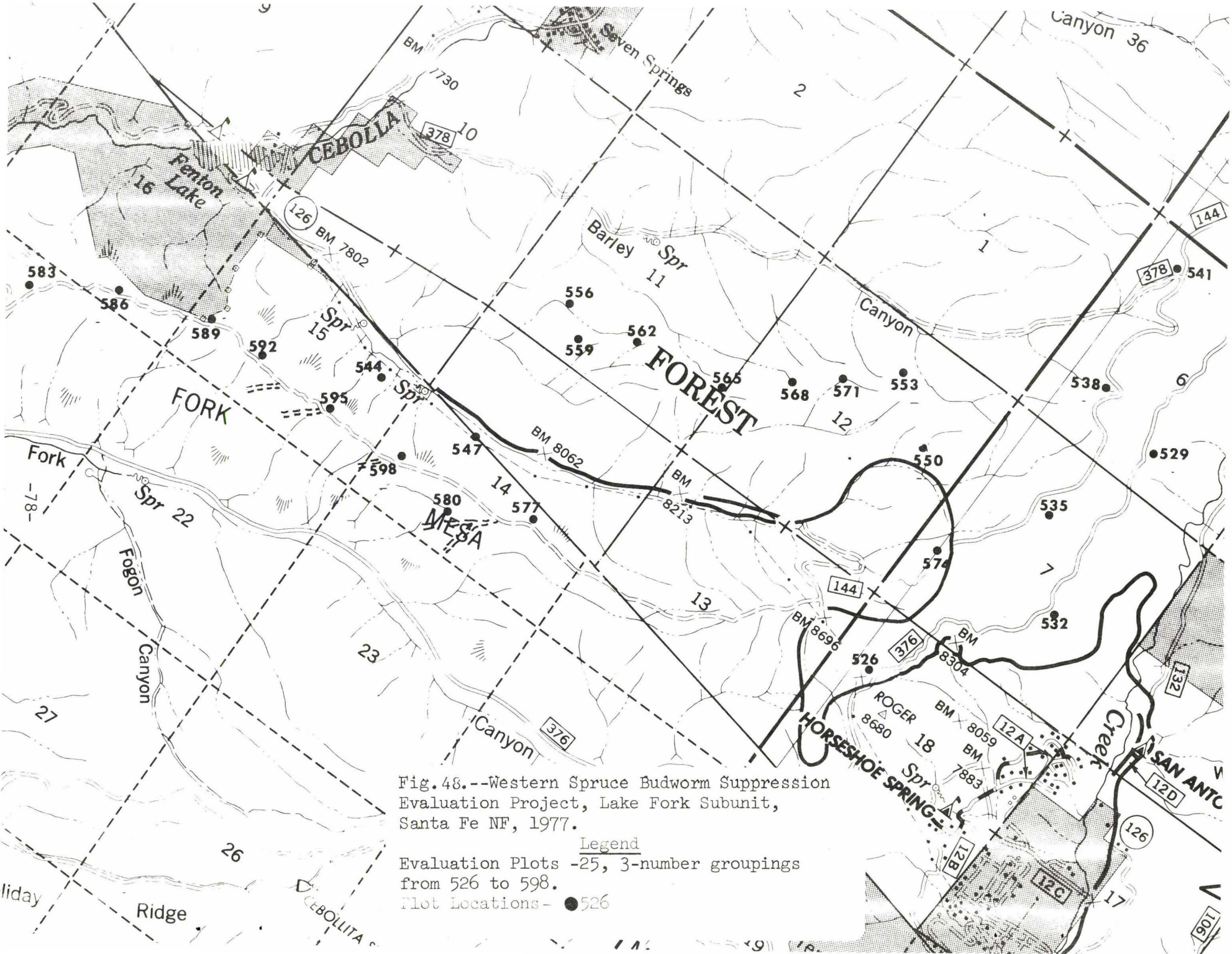


Fig. 48.--Western Spruce Budworm Suppression Evaluation Project, Lake Fork Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots -25, 3-number groupings from 526 to 598.

Plot Locations- ●526

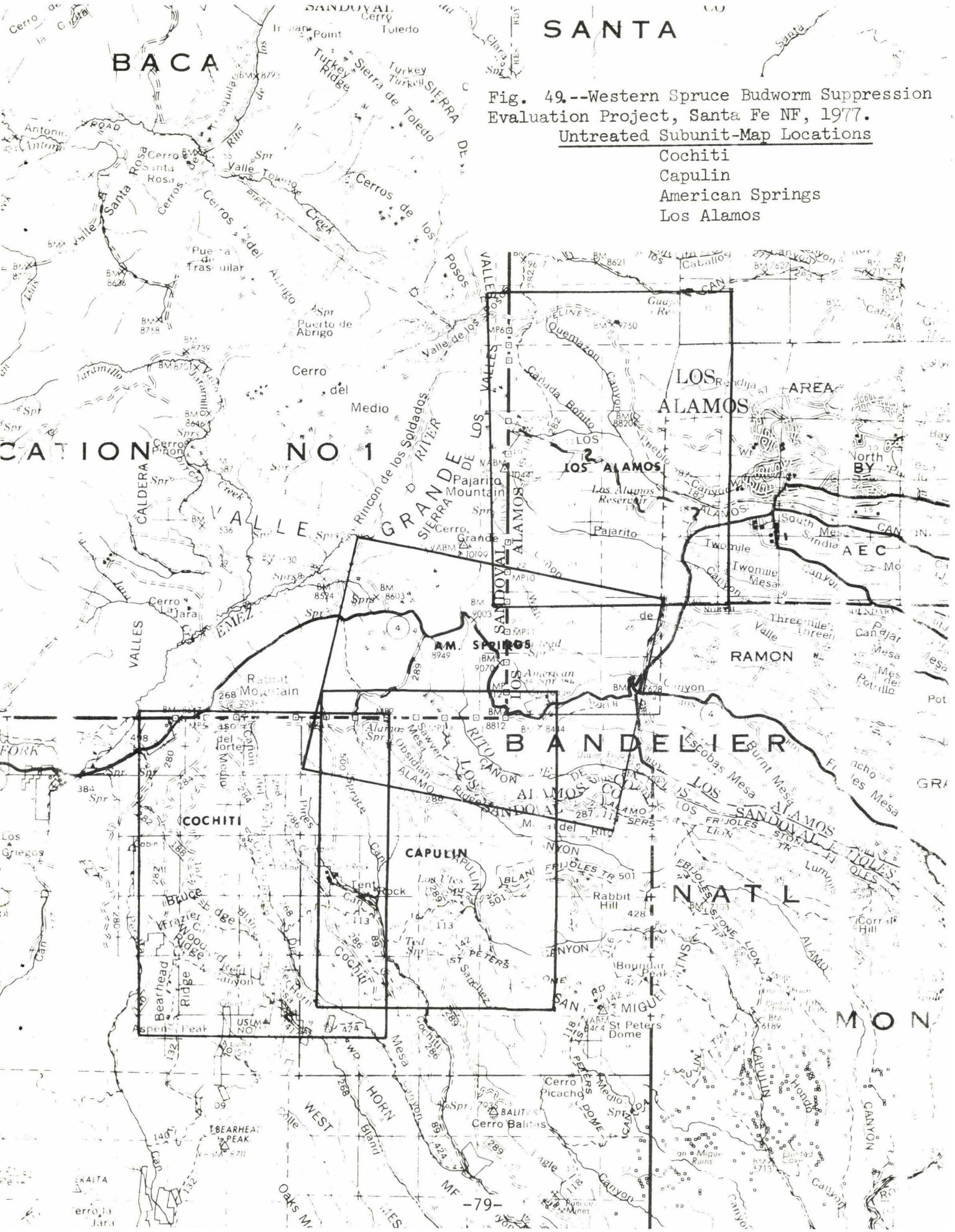


Fig. 49.--Western Spruce Budworm Suppression Evaluation Project, Santa Fe NF, 1977.

Untreated Subunit-Map Locations

Cochiti
Capulin
American Springs
Los Alamos

Fig. 50.--Western Spruce Budworm Suppression Evaluation Project, Cochiti Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots, - 25, 3-number groupings from 601 to 673.

Plot Locations - ●601

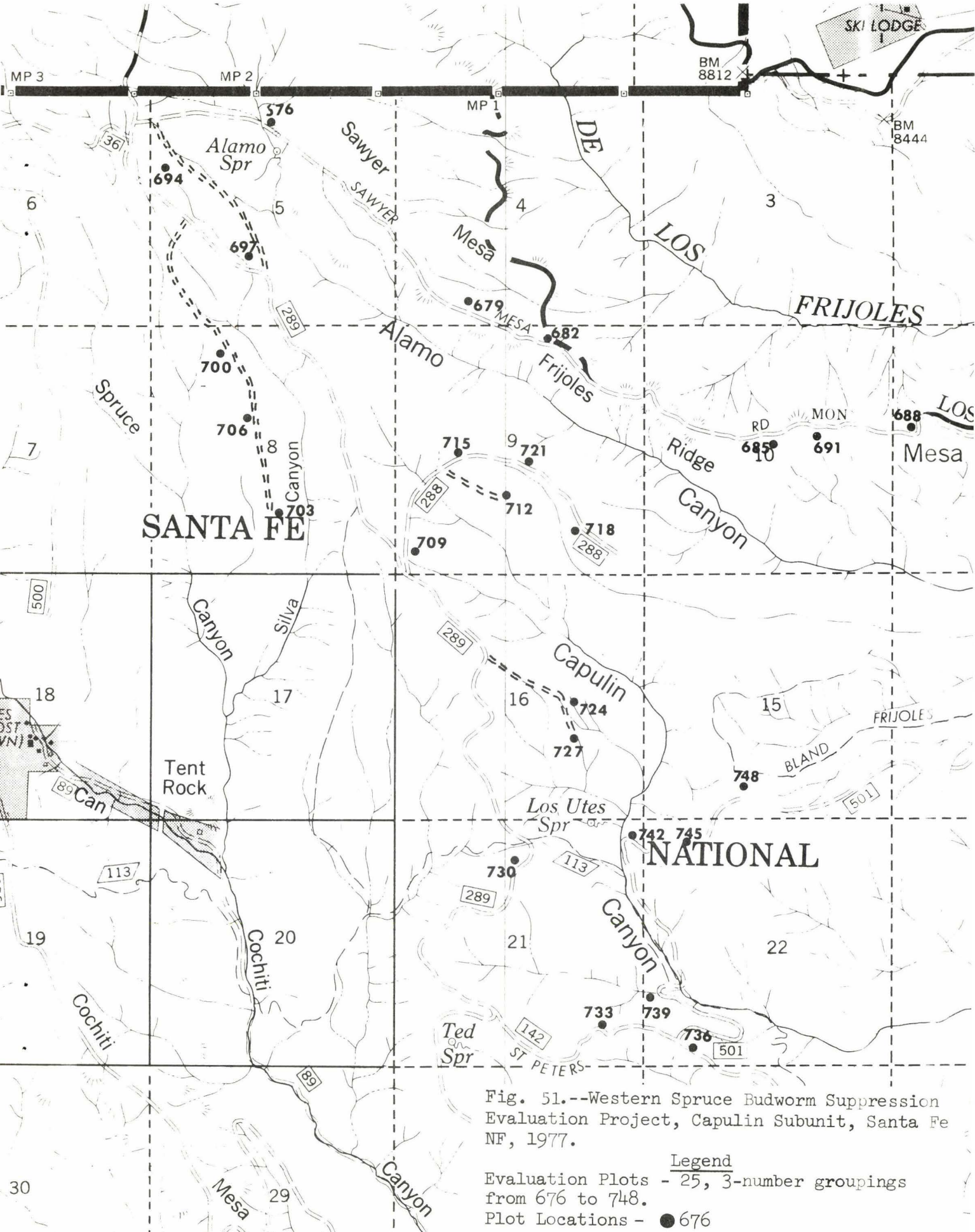


Fig. 51.--Western Spruce Budworm Suppression Evaluation Project, Capulin Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots - 25, 3-number groupings from 676 to 748.

Plot Locations - ● 676

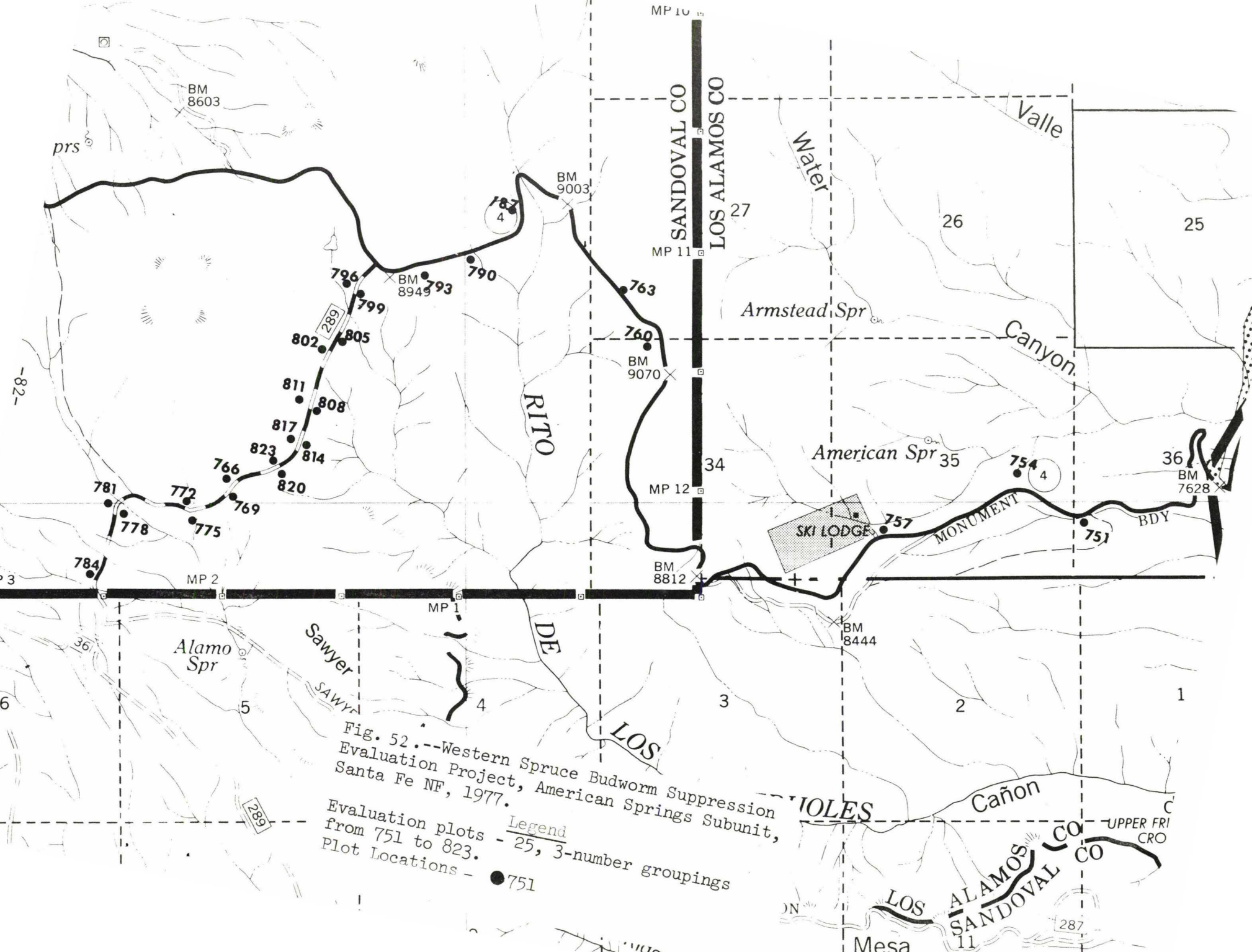


Fig. 52.--Western Spruce Budworm Suppression Evaluation Project, American Springs Subunit, Santa Fe NF, 1977.

Evaluation plots - 25, 3-number groupings from 751 to 823.

Plot Locations - ●751

Legend

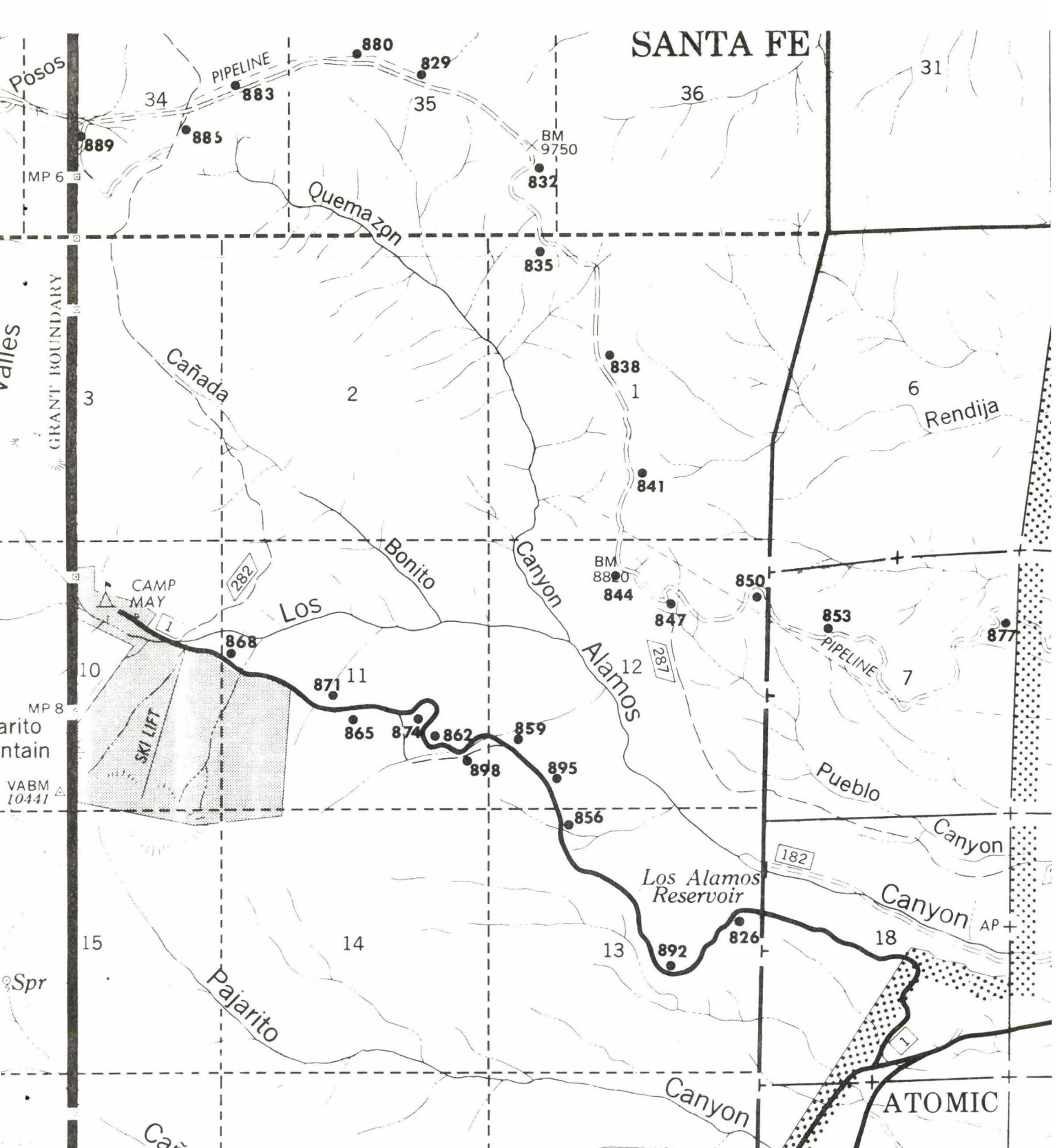


Fig. 53.--Western Spruce Budworm Suppression Evaluation Project, Los Alamos Subunit, Santa Fe NF, 1977.

Legend

Evaluation Plots - 25, 3-number groupings from 826 to 898.

Plot Locations - ●826

2. Timing Insecticide Application

Proper timing of an insecticide application was essential for project success. Because Sevin®-4-oil is a relatively short-lived, non-persistent insecticide, it must be applied to foliage and quickly eaten by larvae to be effective. Early spray applications against small larvae (second and third instars) feeding within unopened buds are ineffective because the population is not likely to ingest the insecticide. Late spray applications, on the other hand, also are ineffective because some of the population may pupate and thus prevent ingestion of the insecticide. Therefore, the insecticide was to be applied when at least 20 percent of the budworm population was in the fifth and sixth larval instars and before 5 percent had pupated.

The timing of application for each treated subunit depended on the extent of budworm larval development within that subunit. Since the subunits were laid out to minimize exposure and elevational differences, larval development and foliage growth were assumed to be relatively uniform throughout each subunit.

Development sampling which lasted from May 16 through June 7 was obtained from five plots located throughout the range of exposure and elevational differences in each subunit. Where access to a portion of a subunit was limited, data from adjacent sampling plots at a similar elevation and exposure were used.

Sample trees were codominant Douglas-firs, 30 to 50 feet in height with some defoliation evident. Budworms were collected from two, 15-inch apical branches cut from the north and south sides of the midcrown of each sample tree with a pole pruner equipped with a collecting bag (Fig. 54).

Each sample branch was placed separately in a plastic bag and transported to the Los Alamos Laboratory. All branches were stored at about 40° F prior to examination for budworm larvae within 24 hours (Fig. 55). Budworm larvae first were separated from other defoliators and then their instar was determined on the basis of physical characteristics.

The percentage of the budworm population in each larval instar was calculated for each subunit. Where the extent of larval development was uncertain, because of insufficient data, the Project Entomologist examined the subunit on the ground before it was released for spraying. Spraying began between 24 and 48 hours after release and was to be completed within 2 consecutive days.

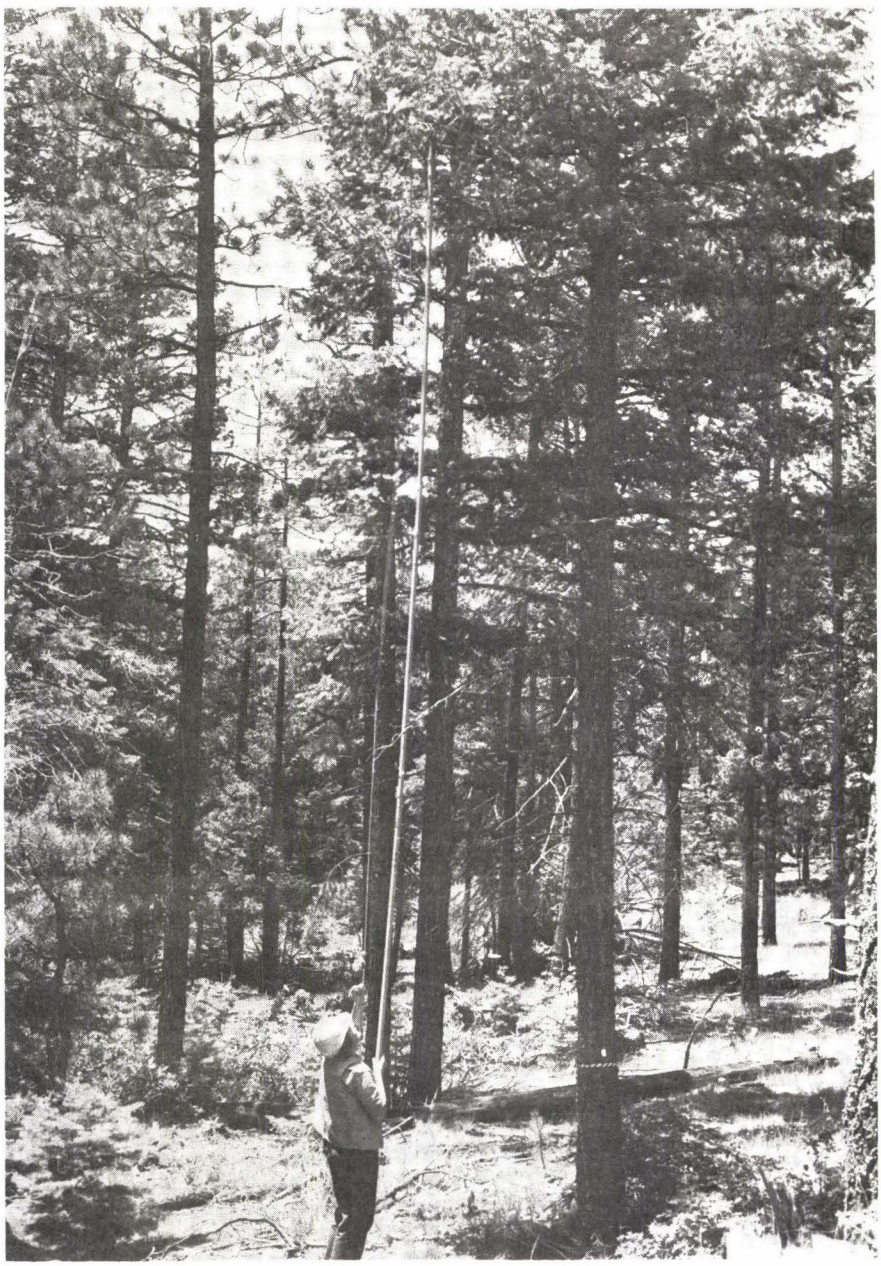


Figure 54.--Cutting branches from the midcrown of sample tree with a pole pruner (collecting bag removed), Santa Fe National Forest, 1977.

Figure 55.--Seasonal employee examining foliage for budworm larvae, Santa Fe National Forest, 1977.

When a subunit was released, but spraying was delayed for 1 week or longer because of poor weather or operational problems, the plan was to take another development sample to determine the proportion of budworm which had pupated. If 5 percent of the budworm larvae in a subunit had pupated, the subunit was to be dropped from the analyses of spray effectiveness, but the subunit was to be sprayed anyway to reduce the population as much as possible.

3. Evaluating Immediate Project Effectiveness

The amount of budworm population reduction in the 1976-7 generation from the insecticide was determined by comparing larval densities and mortality on sprayed and unsprayed subunits. Budworm larval populations were sampled within 2 days prior to spraying and 14 days thereafter. Unsprayed subunits were sampled on the same schedule as if they had been sprayed.

a. Sampling Design

Budworm larval populations were sampled on each of the 25 plots per subunit using a 3-tree cluster. The plot constituted the primary sampling unit for measuring larval population densities. Larval density was expressed as larvae per 100 live buds which gave equal weight to each branch sampled. Plot means were computed by averaging the larval density on each sample branch to the tree and then averaging the 3-tree means.

Sample trees were codominant Douglas-fir, 30 to 50 feet in height, and relatively open-grown with full crowns. Sample branches were cut from opposite sides of the midcrown with pole pruner with collecting bag. Each branch had at least six live buds.

Each branch and all the contents of the collecting bag were placed in an individual plastic bag. All bags from the same tree were bundled together with twine and kept shaded during transport to the laboratory where they were stored immediately in a walk-in cooler at 40° F.

Foliage examination was made within 24 hours of collection. Budworm larvae first were separated from all other larvae and then counted along with budworm pupae and empty pupal cases for each branch. The live buds present per branch also were counted. To estimate larval populations with the same level of accuracy, two branches were taken per tree for the pre-spray sample and four branches for the post-spray sample.

b. Analysis of Larval Mortality

Larval densities and mortalities were computed for each treatment, subunit, and plot for each time period.

(1) Subscripts:

i = treatments	1 = spray	2 = check
j = subunit	j = 1, 6	
k = plot	k = 1, 25	
l = tree	l = 1, 3	
m = branch	m = 1, 4	larval density
	m = 1, 2	egg mass density

(2) Plot Level:

Pre-spray population

$$\text{pre}_{ijk} = \frac{\sum_{l=1}^{3}\sum_{m=1}^{2} \frac{\text{budworm}_{ijklm}}{\text{buds}_{ijklm}}}{6} (100)$$

Post-spray population

$$\text{post}_{ijk} = \frac{\sum_{l=1}^{3}\sum_{m=1}^{4} \frac{\text{budworm}_{ijklm}}{\text{buds}_{ijklm}}}{12} (100)$$

(3) Mortality Calculations:

% Unadjusted plot mortality

$$\text{Mort}_{ijk} = 1.0 - \frac{\text{Post}_{ijk}}{\text{Pre}_{ijk}}$$

% Adjusted plot mortality by Abbott's Formula

$$\text{Mort}_{ijk} = \left[1 - \left(\frac{\text{Post-treat}}{\text{Pre-treat}}\right)\left(\frac{\text{Pre-check}}{\text{Post-check}}\right)\right] \times 100$$

Confidence intervals for the percent larval mortalities were calculated using Simmons and Chen's [3/] Two-Sample Method for the unadjusted mortalities and Four-Sample Method for the adjusted mortalities.

There were 300 plot level values for each variable (2 treatments X 6 subunits X 25 plots = 300).

(4) Subunit level calculations of means and standard errors. Means and standard errors were calculated for each of the three variables at the subunit level. The formulas follow, using X_{ijk} as an example for one of the variables.

$$\overline{X}_{ij} = \sum_{k=1}^{25} X_{ijk}/25,$$ where $\overline{X}_{ij}$ is the mean for the j^{th} subunit in the i^{th} treatment.

$$S.E.\ \overline{x}_{ij} = \sqrt{\frac{\sum_{k=1}^{25} X_{ijk}^2 - \left(\sum_{j=1}^{25} X_{ijk}\right)^2 / 25}{25\ (25-1)}},$$

where S.E. $\overline{x}_{ij}$ is the standard error of the mean $\overline{x}_{ij}$.

(5) Treatment level calculations of means and standard errors. Assumptions made - each of the subunits are independent of each other and are self-weighting.

$$\overline{X}_i = \sum_{j=1}^{6} \overline{X}_{ij}/6$$ where $\overline{X}_i$ is the mean for the i^{th} treatment.

$$S.E.\ \overline{x}_i = \sqrt{\sum_{j=1}^{6} S.E.\ \overline{x}_{ij}^2}$$

(6) Statistical tests comparing the two populations (treatments - spray versus check).

For populations with possibly different means but a common variance, the general linear model can be expressed by the following:

3/ Simmons, G. A. and C. W. Chen. 1975. Approaches to assessing insecticide efficacy in spruce budworm (Lepidoptera:Tortricidae) control programs. Can. Ent. 107:1205-1209.

$X_{ij} = u + T_i + E_{ij}$, where X_{ij} is the observation of interest in the jth plot of the ith treatment, and T_i is the effect of the treatment mean and with a random error term E_{ij}. The subscript j now represents all of the plots from each subunit in the ith treatment. j = ~~1~~150.

Some plots lost in 1977 & 1978.

The various hypothesis to be tested are:
H1 pre-spray populations are equal
H2 post-spray populations are equal
H3 mortality is equal

Each of these hypothesis was tested at the 95 percent confidence level using the following procedures:

$$t = \frac{\bar{X}1 - \bar{X}2}{S(\bar{x}1 - \bar{x}2)}$$

Where $\bar{X}1$, $\bar{X}2$ are the means from the spray and check population, and $S(\bar{x}1 - \bar{x}2)$ is the standard error of the difference of $\bar{x}1$ and $\bar{x}2$, and is computed as

$$S(\bar{x}1 - \bar{x}2) = \sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}$$

The degrees of freedom associated with t are d.f. = $(n_1-1) + (n_2 -1)$.

4. Evaluating Long-term Project Effectiveness

Plans were to assess budworm population reduction from the insecticide through the 1978-9 generation using three measures of budworm density: bud-mining larvae, late-instar larvae and egg masses.

All three measures were obtained during 1977. The larval densities were from the 1976-7 generation, while the egg mass densities were from the 1977-8 generation.

a. Sampling Design

Budworm larval population densities were estimated from the 25 plots established per subunit using two, 3-tree clusters. Sample trees met the criteria of Section III, B., 2. One cluster was used for both bud-mining larvae and egg masses, while the other cluster for late-instar larvae corresponded to the pre-spray sample established for measuring immediate project effectiveness.

(1) Sampling Bud-Mining Larvae

Four, 15-inch branches from each quadrant of the lower crown third were cut from each sample tree with a pole pruner equipped with a collection bag. Each branch had to have at least six live buds, half of which still had their bud caps. On each branch, all live buds were counted and removed in the field and stored in 70 percent ethanol. Stored buds were examined for bud-mining larvae at a later date in the laboratory (Fig. 56). Budworm larvae were separated from other lepidopterous larvae, and counts made of each.

(2) Sampling Late-instar Larvae

The procedures established in Section III, B., 3., a., were to be used each year for obtaining larval densities of later instars. The instar distribution was to be determined annually for each treatment and subunit.

(3) Egg Mass Sampling

In late August, two, 70 cm midcrown branches were to be cut from opposite sides of each sample tree using a pole pruner with collecting bag. The maximum length and width of each cut branch was measured to calculate foliated branch surface area. Each branch then was individually bagged in 1/4-bushel paper sacks which were transported to the laboratory where they were stored at about 40° F prior to examination.

Foliage from all branches was examined under ultraviolet light for egg masses. Needles bearing egg masses were classed as from current year's foliage or a previous year and kept separate in labeled pill boxes. New egg masses (deposited in the year of sampling) were separated from old egg masses (deposited in the year(s) before sampling) under a stereomicroscope. All egg masses on current year's foliage were classed as new and their characteristics formed the basis for aging those egg masses found on the previous year's foliage.

b. Analysis of Population Reduction

Estimates of each type of population density per plot were to be computed for each sampling period; year 1, year 2, and year 3. Larval densities were expressed as the number of bud-mining larvae per 100 live buds per 4, 15-inch branches or late-instar larvae per 100 live buds per 15-inch branch. Egg mass density were expressed as number of new masses per square meter (1550 sq., in.). Subunit and treatment level means and standard errors were computed as in Section III, 3., b.

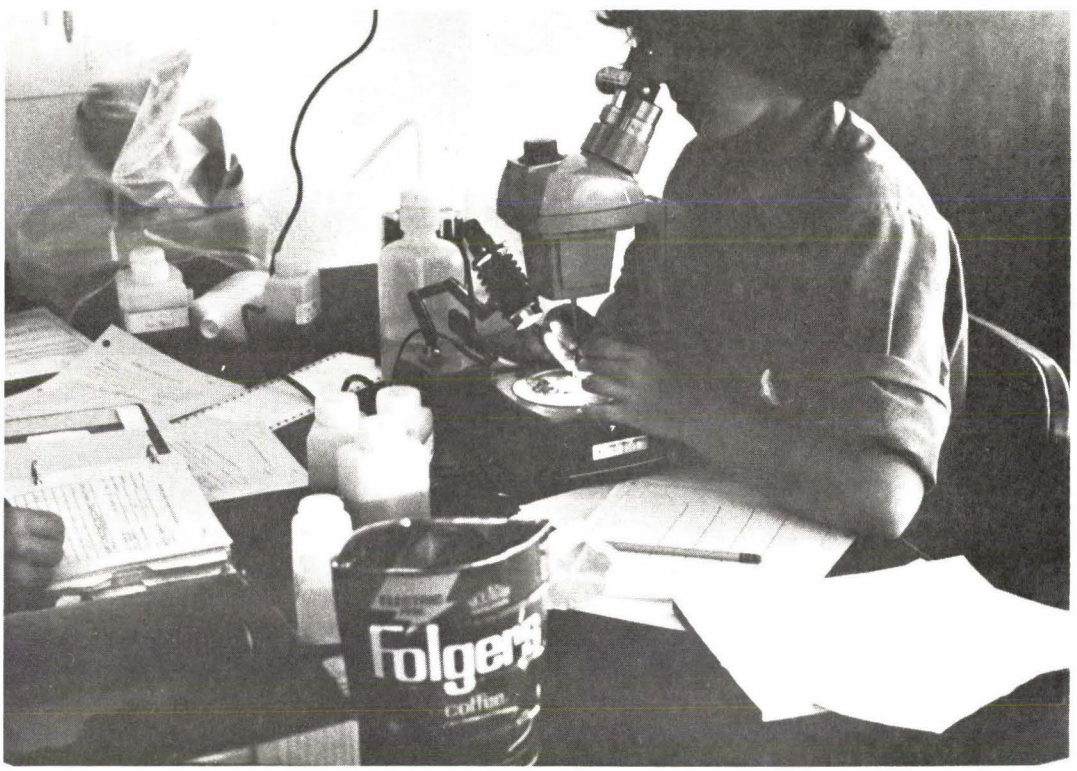


Figure 56.--Seasonal employee examining buds for bud-mining larvae, Santa Fe National Forest, 1977.

Budworm densities were to be compared for the same year between the sprayed and unsprayed check populations as well as comparing the densities between years for the same populations. Procedures for making the tests were the same as in Section III, B., 3., b.

(1) Assumption: Subsequent yearly samples are independent, taken from the same population.

(2) Hypotheses to be tested:

	Treatment		Checks
H1:	year 1 = year 2		year 1 = year 2
H2:	year 2 = year 3		year 2 = year 3
H3:	year 1	=	year 1
H4:	year 2	=	year 2
H5:	year 3	=	year 3

If the treatment effectiveness is long-term, the graph in Figure 57 depicts how the outcome may appear.

Expected results from the various hypothesis:

H3: Expect to be the same
H4, H5: Expect to be different
H1, H2: For the checks, expect to be the same
H1: For treated, expect to be different
H2: For treated, expect to be the same

Since all data can be pooled for the same population and treated as one sample, i.e., 25 plots for each of six subunits or 150 observations, the test for a difference would be extremely sensitive. However, the intent is not to be able to detect small differences, but rather to be able to state that the residual population in the treated population remains at a low endemic level, say 2-5 budworm per 100 buds.

Further work in time series analysis, i.e., continuous sampling from the same population, is to be evaluated to see if other forms of analysis would be more appropriate.

C. Results and Discussion

1. Timing Insecticide Application

Treated subunits were released for spraying on June 7, in the following sequence: Red Top, Blue Bird, Joaquin, San Miguel, Trail, and Smokey Bear. The sequence was based on the following developmental data which compares all subunits:

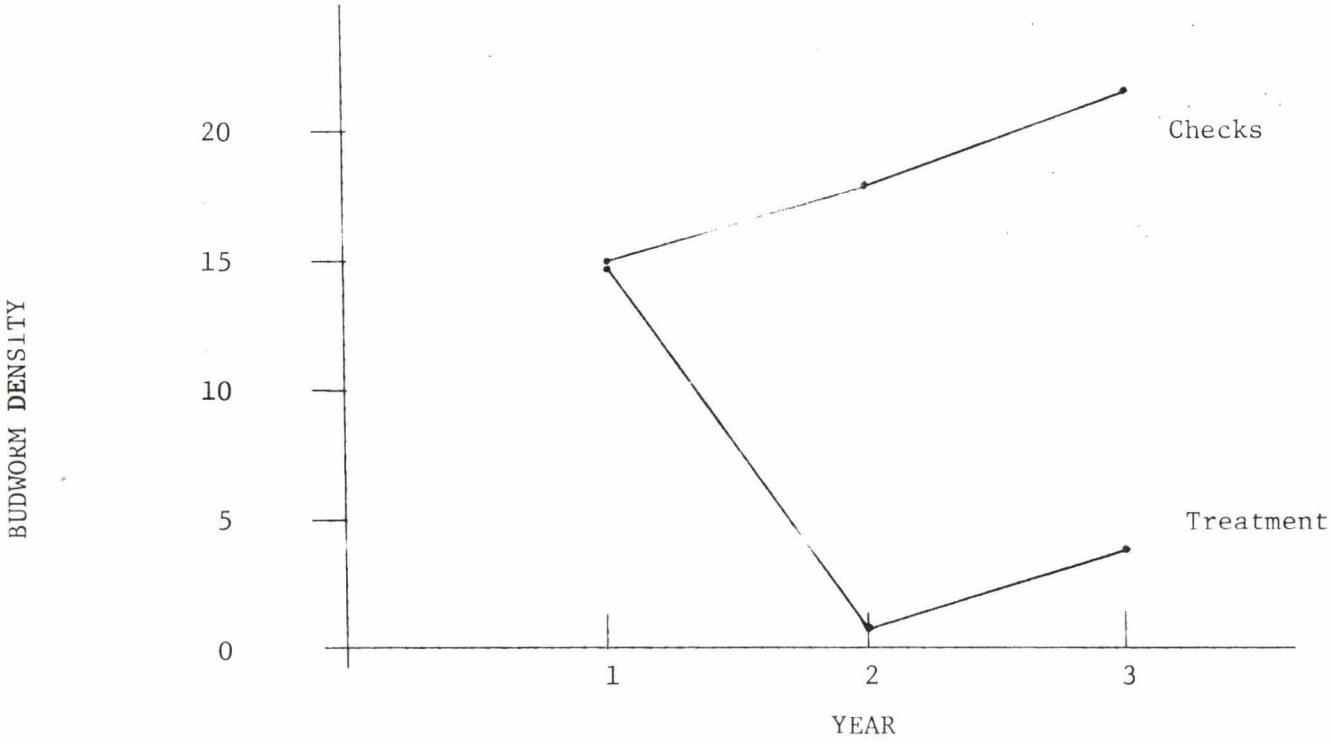


Figure 57.--This graph depicts how the treatment may affect the budworm population over a 3-year period, Santa Fe National Forest, 1977.

Treated Subunits		% in 5th and 6th Larval Instars
1.	San Miguel	41
2.	Joaquin	47
3.	Smokey Bear	7
4.	Trail	31
5.	Blue Bird	40
6.	Red Top	60
Untreated Subunits		
7.	Ojitos	58
8.	Lake Fork	61
9.	Cochiti	53
10.	Capulin	56
11.	American Springs	41
12.	Los Alamos	40

The development samples contained no pupae.

The larval sampling and insecticide application schedule for each subunit is shown in Table 11. Spraying was conducted within 2 consecutive days on all treated subunits except Smokey Bear. Most of Smokey Bear subunit was treated in 2 days and that portion treated the third day contained no evaluation plots. The Red Top subunit was re-treated because spray deposit data indicated that parts of the subunit were not sprayed the first time. None of the retreated areas were resampled because they were intermingled with areas which had received adequate spray coverage initially.

2. Evaluating Immediate Project Effectiveness

The 1976-7 budworm generation in the sprayed area was reduced by 93.1% $\pm$ 1.9% compared with a 44.5% $\pm$ 12.1% reduction in the unsprayed check area. The mortality figures were adjusted for "natural losses" by Abbott's formula to give an 87.5% $\pm$ 4.4%.

The densities of budworm populations within 2 days prior to spraying and 14 days thereafter, are presented for each subunit in Table 12. Prespray larval densities were similar in all subunits except number 7 (Ojitos) which had an average density of about one-third that of the other units. Because of this disproportionately low larval density, the Ojitos subunit was omitted from the data analyses of project effectiveness. Nevertheless, knowledge of budworm populations in Ojitos is considered important for a more complete understanding of project

Table 11.--Western spruce budworm suppression-evaluation project larval sampling and insecticide application schedule, Santa Fe National Forest and Jemez Pueblo lands, 1977.

Date	Treated Subunits						Untreated subunits					
	1	2	3	4	5	6	7	8	9	10	11	12
June 8								25-Pre	25-Pre	22-Pre		
9						25-Pre					25-Pre	
10					25-Pre	Spray						14-Pre
11		25-Pre			Spray	Spray						11-Pre
12	25[a]-Pre	Spray					13-Pre					
13	Spray	Spray		18-Pre			12-Pre					
14	Spray			7-Pre								
15			25-Pre	Spray								
16			Spray	Spray								
17			Spray									
18			Spray[b]			Spray						
19						Spray						
20												
21												
22												
23								25-Post	25-Post	22-Post		
24						18-Post					25-Post	
25					25-Post	7-Post						14-Post
26		25-Post										11-Post
27	25-Post						13-Post					
28				18-Post			12-Post					
29				7-Post								
30			25-Post									

a/ Number of evaluation plots sampled that day.
b/ The area treated on the third day contained no evaluation plots.

Table 12.--Western spruce budworm suppression-evaluation population densities and mortality, Santa Fe National Forest and Jemez Pueblo lands, 1977.

Subunits	No. of plots	Budworm per 100 buds				Percent budworm mortality	
		Pre-spray		14-day Post-spray			
		Mean	S.E.[a/]	Mean	S.E.[a/]	Unadjusted	Abbotts
Sprayed							
1	25	20.5	2.5	1.7	0.4	91.9	
2	25	11.9	2.1	0.7	0.2	94.2	
3	25	11.7	1.7	1.1	0.3	90.7	
4	25	17.9	2.2	1.0	0.2	94.2	
5	25	18.2	2.8	1.1	0.4	94.1	
6	25	9.0	1.1	0.6	0.2	92.9	
Combined All subunits	150	14.9	9.9	1.0	0.1	93.1 + 1.9[b/]	87.5 + 4.4
Unsprayed (Check)							
7	25	2.7	0.4	0.8	0.2	67.7	
8	25	9.5	1.8	5.8	1.0	39.0	
9	25	8.7	1.5	4.6	0.8	47.6	
10	22[c/]	17.7	3.0	7.8	1.2	56.0	
11	25	12.6	2.1	8.3	1.5	33.8	
12	25	14.3	2.2	8.1	1.2	43.3	
Combined[d/]	122	12.4	1.0	6.9	0.5	44.5 ± 12.1	

a/ Standard errors for each subunit are the within subunit sampling error based on the number of plots. The standard error of the combined mean is based on all the observations for each treatment (i.e., sprayed or unsprayed).

b/ Mortality confidence intervals calculated at the 95% level.

c/ Three plots destroyed by La Mesa Fire of June 16-23, 1977.

d/ Subunit No. 7 (Ojitos) omitted because of its disproportionately low population density.

effects. Since the larval density in Ojitos is characteristic of population levels for several miles east of the sprayed area, the chances for re-infestation are minimal. Continued annual sampling in Ojitos is needed to asses the influence of surrounding budworm populations on any resurgence which may occur within the sprayed area.

The prespray population density in the sprayed area did not differ significantly ($P<.05$) from that in the unsprayed check area. Density estimates expressed as average number of larvae per 100 buds were 14.9 $\pm$ 1.8 for the sprayed area and 12.4 $\pm$ 2.0 for the unsprayed check area.

There was a highly significant difference ($P<.01$) in the post-spray population density between each area. The average numbers of larvae and pupae per 100 buds were estimated as 1.0 $\pm$ 0.2 in the sprayed area and 6.9 $\pm$ 1.0 in the unsprayed area.

3. Evaluating Long-term Project Effectiveness

First-year estimates were made of three measures of budworm population densities considered important for assessing long-term project effectiveness. These estimates will form the basis for comparison in all subsequent annual sampling.

a. Bud-Mining Larvae

The densities of bud-mining larvae in each subunit is presented in Table 13. The sprayed subunits combined mean of 8.0 $\pm$ 1.3 larvae per 100 buds did not differ significantly ($P<.05$) from the mean of 8.4 $\pm$ 2.0 for the unsprayed subunits.

Non-budworm lepidopterous larvae comprised only about 2 percent of the total found within buds. The most common associates were the tortricids, Argyrotaenia dorsalana (Dyar) and A. provana (Kearfott)[4/], based on rearings from late-instar budworm sampling.

b. Late-instar Larvae

The pre-spray larval densities presented in Table 12 provide the first-year estimates of budworm populations during the late larval instars. There was no significant difference ($P<.05$) between the density of 14.9 $\pm$ 1.8 larvae per 100 buds in the sprayed area and 12.4 $\pm$ 2.0 in the unsprayed check area.

4/ Determinations made by J. A. Powell, University of California, Berkeley, California, from adults.

Table 13.--Western spruce budworm suppression-evaluation project budmining larval densities, Santa Fe National Forest and Jemez Pueblo lands, 1977.

Subunits	No. of plots	Budworm per 100 buds		% other Lepidoptera larvae
		Mean	S.E.	
Sprayed				
1	13	11.9	2.0	2.1
2	21	7.8	1.6	1.9
3	25	5.6	1.0	5.3
4	20	9.9	2.2	1.8
5	19	8.0	2.1	2.2
6	19	6.8	1.4	1.3
Combined	117	8.0	0.7	2.3
Unsprayed (Check)				
7	25	1.3	0.3	1.2
8	22	7.2	1.6	0.8
9	21	5.8	1.6	7.6
10	18	8.0	1.8	5.4
11	25	5.9	1.5	1.0
12	23	14.9	3.6	1.3
Combined[a/]	109	8.4	1.0	2.4

a/ Subunit No. 7 (Ojitos) omitted because of its disproportionately low population density.

The distribution of larval instars in the pre-spray samples are shown in Table 14 for each spray subunit and the unsprayed area. For the entire sprayed area, 84.1 percent of the budworm were in the fifth and sixth larval instars and 0.3 percent were pupae. For the unsprayed check area, 75.7 percent of the budworm were in the fifth and sixth larval instars and 0.4 percent were pupae. This instar distribution was well within the project goal of at least 20 percent in the fifth and sixth larval instar, but no more than 5 percent as pupae.

The densities of bud-mining and late-instar larvae were tested for linear association, since it was assumed that high plot densities during bud-mining would be associated with high plot densities of late-instar larvae. Analysis of the data collected in 1977 gave a correlation coefficient (R) of 0.55 which was highly significant ($P < .01$). Although this indicates a real linear association between the two measures of larval density, the coefficient of determination (R^2) was only 0.30. This indicates only about one-third of the variation in late-instar larval density was associated with the bud-mining density. Because of this low R^2 value and other problems associated with scheduling bud collection and the time consuming work of bud examination and sorting larvae, no future bud-mining samples will be taken on the project. Rather, the late-instar larval sample will be the basis for annual assessment of long-term changes in larval populations.

c. Egg Masses

The egg mass densities for each subunit is shown in Table 15. Within the sprayed area there was an average of 1.6 ± 1.1 new egg masses per square meter of foliage or 1.0 ± 0.3 new egg masses per 1,000 square inches. This density was right at the level considered adequate for a successful population reduction in the generation following treatment.

Egg mass density in the unsprayed check area averaged 11.2 ± 2.0 per square meter of foliage or 7.2 ± 1.3 per 1,000 square inches. Thus, regardless of how egg mass density is expressed, density in the unsprayed area was about seven times greater than in the sprayed area. This initial difference in the 1977-8 generation between treatment and check should be reflected in the second-year estimates of larval densities in June 1978. Egg mass sampling will continue in 1978 to permit early assessment of any budworm population changes in the 1978-9 generation.

Table 14.--Western spruce budworm suppression-evaluation project larval instar distribution from pre-spray samples, Santa Fe National Forest and Jemez Pueblo lands, 1977.

Treated subunits	Sample dates	Number of budworm						
		Larval instar					Pupae	Total
		II	III	IV	V	VI		
San Miguel	6/12	0	0	135	768	581	2	1,486
Joaquin	6/11	0	2	67	333	211	0	613
Smokey Bear	6/15	0	10	85	145	237	6	483
Trail	6/13-14	0	4	116	407	515	6	1,048
Blue Bird	6/10	0	0	229	452	252	0	933
Red Top	6/9	2	22	137	294	136	0	591
Totals		2	38	769	2,399	1,932	14	5,154
Percentile		0.1%	0.7%	14.9%	46.6%	37.5%	0.3%	100%

Untreated subunits	Sample dates	Number of budworm						
		Larval instar					Pupae	Total
		II	III	IV	V	VI		
Totals[a/]	6/8-13	0	25	338	623	527	6	1,519
Percentile		0%	1.6%	22.3%	41.0%	34.7%	0.4%	100%

a/ Represents a random sample from all the untreated subunits.

Table 15.--Western spruce budworm suppression-evaluation project egg mass densities, Santa Fe National Forest and Jemez Pueblo lands, 1977.

Subunits	No. of plots	Egg masses per square meter of foliage[a/]	
		Mean	S.E.
Sprayed			
1	25	4.1	1.1
2	25	1.3	0.5
3	25	0.2	0.1
4	25	1.7	0.5
5	25	1.3	0.5
6	25	1.0	0.3
Combined	150	1.6	0.5
Unsprayed (Check)			
7	25	0.9	0.3
8	25	7.5	1.7
9	25	11.1	2.7
10	22	13.6	2.2
11	25	7.1	1.0
12	25	16.9	2.5
Combined[b/]	147	11.2	1.0

a/ To obtain densities per 1,000 square inches of foliage, multiply figures by 0.6452.

b/ Subunit No. 7 (Ojitos) omitted because of its disproportionately low population density.

IV. TREE DAMAGE APPRAISAL PHASES

A. Objectives

1. Evaluating Defoliation

a. Immediate

Determine the amount of foliage saved on both Douglas-fir and white fir in the treatment year.

b. Long-term

Determine the relationship between the number of budworm egg masses deposited per 1000 square inches of foliage with the amount of defoliation the following year.

2. Evaluating Tree Growth Loss

Determine the relationship between the amount of defoliation and changes in radial growth increment.

3. Evaluating Tree Mortality and Top-Kill

a. Seedling and Sapling

Determine the amount of seedling and sapling mortality and changes in species composition.

b. Sawtimber

Determine the amount of tree mortality and top-kill caused by different degrees of defoliation.

B. Methods

1. Evaluating Defoliation

a. Immediate

Fifteen of the 25 plots in each subunit were randomly selected for estimating defoliation on Douglas-fir. Also, 15 white fir plots were sampled in 8 subunits (subunits 2, 3, 4, and 5 in the treatment area and 8, 9, 10, and 11 in the untreated area). The white fir plots were adjacent to and had the same number as the Douglas-fir plots. On all plots, 3 codominant Douglas-fir and white fir trees, 30-50 feet tall, with relatively open-grown crowns were sampled. A list of the plots where samples were collected are shown in Table 16 (Figures 38-53).

Table 16.--The following plots were sampled for tree defoliation and damage, Santa Fe National Forest, 1977.

San Miguel	Joaquin	Smokey Bear	Trail	Blue Bird	Red Top	Ojitos	Lake Fork	Cochiti	Capulin	American Springs	Los Alamos
1	76	151	226	301	376	451	526	601	676	751	826
7	82	154	229	304	382	454	529	604	697	757	829
10	91	160	235	313	388	460	544	610	700	760	832
13	94	163	247	316	391	469	547	616	706	763	844
22	97	166	250	322	397	472	550	625	709	766	850
25	100	169	253	325	400	475	553	631	712	772	853
28	103	172	256	328	406	478	556	634	715	775	856
34	109	181	262	334	418	481	559	640	721	781	865
37	112	190	265	343	427	484	562	643	724	784	868
49	121	193	268	349	430	493	565	646	727	793	871
52	127	199	271	352	433	496	577	652	730	802	877
58	130	208	274	355	436	514	580	658	733	805	880
61	133	214	277	361	439	517	583	661	736	814	883
64	136	217	286	367	442	520	595	664	739	817	889
70	145	220	289	373	445	523	598	670	745	820	898

Sample branches consisted of 4 apical branches (27.5 inches in length) taken from opposite quadrants at midcrown of each sample tree. From each of these branch samples, 25 new shoots were examined for current defoliation using the left side of one branch and the right side of another, and so on. Each new shoot was individually examined for defoliation and assigned an index value as follows:

6-class			4-class		
Defoliation class %	Index value	Midpoint value %	Defoliation class %	Index value	Midpoint value %
0	0	0			
1-25	1	12.5	0-25	1	12.5
26-50	2	37.5	26-50	2	37.5
51-75	3	62.5	51-75	3	62.5
76-99	4	87.5	76-100	4	87.5
100	5	100			

Defoliation estimates were analyzed on a "per plot" basis. The 6-class system is readily convertible to the 4-class system by assigning all zero percent defoliation values an index value of 1 and all 100 percent defoliation values an index value of 4.

The following formulas were used to determine the percent defoliation on a "per plot" basis.

4-Class

$$\text{Percent defoliation} = \frac{n_1\,(12.5) + n_2\,(37.5) + n_3\,(62.5) + n_4\,(87.5)}{N}$$

6-Class

$$\text{Percent defoliation} = \frac{n_1\,(12.5) + n_2\,(37.5) + n_3\,(62.5) + n_4\,(87.5) + n_5\,(100)}{N}$$

where n_1 = number of twiglets with index value 1
n_2 = number of twiglets with index value 2
n_3 = number of twiglets with index value 3
n_4 = number of twiglets with index value 4
n_5 = number of twiglets with index value 5
N = total number of twiglets examined per plot = 300

b. Long-term

The same methods used to evaluate immediate defoliation will be used to evaluate long-term defoliation. Regression analysis will be used to compare the number of egg masses per 1000 square inches of

foliage in 1977 to percent defoliation in 1978. This relationship will be examined again for 1978 egg masses and 1979 defoliation and for 1979 egg masses and 1980 defoliation.

2. Evaluating Tree Growth Loss

In 1980, increment core samples will be taken on each of the Douglas-fir and white fir trees used for defoliation estimates. In addition to the host trees, one non-host (ponderosa pine) tree on each plot will be sampled. Three increment cores, 120 degrees apart, will be taken at d.b.h. per sample tree. Core samples will be placed in paper straws for storage. Straws will be labeled as to subunit, plot, and tree number and species. Cores will be stored in a cooler prior to measurement.

Core samples from the non-host trees will be used to determine the expected growth in host trees. Percent growth above and below the expected value will be determined for host trees on a "per plot" basis. Percent growth will then be compared to percent defoliation for each year from 1977 through 1980.

3. Evaluating Tree Mortality and Top-Kill

a. Seedling and Sapling Mortality

Seedling and sapling (0.1 to 4.9 inches d.b.h.) mortality was evaluated on all 25 plots in each of the treated and untreated subunits. On each plot, a permanent 1/100-acre circular subplot was established. All seedlings and saplings on the subplot were recorded by tree species and damage (live or dead). Trees with a d.b.h. of 0.5 to 4.9 inches were considered as saplings. Trees with a d.b.h. of less than 0.5 inches, or trees less than 4.5 feet in height, were considered as seedlings.

b. Sawtimber

Tree mortality and top-kill were evaluated in both the treatment and untreated subunits. Twelve 1-acre plots were photographed at a scale of 1:3300 on a photographic strip in each of the 12 units. A forward overlay of 60 percent was used. The aerial platform consisted of a Cessna 206 aircraft equipped with a 70 mm Hasselblad EL/M camera, a 250 mm lens, and Wratten 12 filter equivalent, using 2443 infrared aerial Kodak film. The film was interpreted with a Bausch and Lomb 240 Z steroscope, mounted on a light table.

Eleven ground truth plots (5 treatment and 6 untreated subunits) were selected for ground examination. One plot in a treatment subunit was not checked because of adverse weather. This plot will be examined in the spring of 1978, and the analysis adjusted in a future

report. A hand-held stereo viewer, with an independent light source, was used to view the photo plots in the field for establishing boundaries. One side of the boundaries of the ground plots was measured using slope correction factors. Plot corners were staked, and string was used to delineate boundaries. All mortality and top-kill within plots were recorded.

Double sampling with regression was used to obtain an estimate of mortality and top-kill in the treatment and untreated units.

The following prediction equation was used to obtain an adjusted estimate of trees per plot (Wear et al. 1966 [5/]):

$$\bar{Y}Rd = \bar{Y}_2 + b\ (\bar{x}_1 - \bar{x}_2)$$

where:

YRd = estimate of average number of dead or damaged trees from a regression double sample

Y_2 = mean of all field plot measurements in the ground truth subsample

b = regression coefficient of field on photo measurements from those plots that have both photo and ground truth data

$\bar{x}_1$ = mean photo measurement of numbers of dead or damaged trees from the large sample of photo plots

$\bar{x}_2$ = mean photo measurement of number of dead or damaged trees from only those plots with ground truth measurements

C. Results

1. Evaluating Defoliation

a. Immediate

Percent defoliation by subunit for white fir and Douglas-fir are given in Table 17 for both the 4- and 6-class systems. Percent foliage saved using the 4-class system for Douglas-fir and white fir was 11 and 19, respectively. Percent foliage saved using the 6-class system for Douglas-fir and white fir was 14 and 24, respectively.

5/ Wear, J.F., R. B. Pope, and P. W. Orr. 1966. Aerial photographic techniques for estimating damage by insects in Western forests. USDA. Forest Service. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon.

Table 17. Percent defoliation by subunit for white fir and Douglas-fir Calculations are given for both the 4- and 6-class systems. Santa Fe National Forest, 1977.

	4-class		6-class	
	% defoliation		% defoliation	
Treatment Unit	White fir	Douglas-fir	White fir	Douglas-fir
Subunit				
1		44.08		41.59
2	33.88	26.97	28.55	19.86
3	29.52	24.34	24.76	17.95
4	52.53	40.33	53.13	37.05
5	44.00	31.43	41.75	25.76
6		24.67		16.60
Unit average	39.98	31.97	37.05	26.47
Untreated Unit				
Subunit				
7		21.39		14.13
8	59.03	51.32	62.20	51.07
9	51.70	40.39	52.80	37.21
10	60.57	51.45	63.62	51.16
11	63.63	38.10	66.38	34.21
12		55.94		56.74
Unit average	58.73	43.10	61.25	40.75

The 6-class system provides a better estimate of the actual defoliation compared to the 4-class system. Using the 4-class system, it is evident that trees having an actual defoliation of between 0-12.5 percent are all categorized as having 12.5 percent defoliation. It is possible, therefore, to have a tree which has never been defoliated assigned a defoliation value of 12.5 percent. On the other end of the spectrum, defoliation values between 87.6 and 100 percent are unattainable. Therefore, a tree totally defoliated would be assigned a defoliation value of 87.5 percent. With the 6-class system, the entire spectrum of defoliation values is utilized. More importantly, below 40 percent defoliation, the 4-class system overestimates the actual defoliation, and above 60 percent defoliation, the 4-class system underestimates the actual defoliation. The two systems compare favorably between about 40 and 60 percent defoliation.

b. Long-term

Defoliation estimates on both Douglas-fir and white fir will be taken annually in both the treated and untreated subunits through at least 1980.

2. Evaluating Tree Growth Loss

Increment cores will be taken in 1980 from all trees sampled for defoliation. Growth loss will be compared to defoliation for each year from 1977 through 1980.

3. Evaluating Tree Mortality and Top-Kill

a. Seedlings and Saplings

Seedlings and saplings per acre are broken down into four diameter classes (0.1 to 0.4 d.b.h. for seedlings, and 0.5 to 1.9, 2.0 to 3.4, and 3.5 to 4.9 d.b.h. for saplings). The number of both seedlings and saplings per acre was greater in the untreated area than in the treated area (Table 18).

Though there was a difference in stocking level between the two units, the percent stocking was relatively comparable:

	Percent seedling and sapling stock			
	Douglas-fir	White fir	Spruce	Ponderosa pine
Treated	39	53	3	5
Untreated	41	48	2	9

Table 18.--Stand composition of Douglas-fir, white fir, spruce, and ponderosa pine seedlings and saplings for the treated and untreated units, Santa Fe National Forest, 1977.

	Seedlings			
	Treated unit		Untreated unit	
	# trees/ acre	% composition	# trees/ acre	% composition
Douglas-fir (live)	90.7	42.2	143.5	37.9
(dead)	2.0	0.9	4.1	1.1
White fir (live)	110.0	51.2	191.2	50.5
(dead)	2.7	1.3	6.1	1.6
Spruce (live)	6.7	3.1	6.1	1.6
(dead)	0	0	1.4	0.4
Ponderosa pine	2.7	1.3	26.5	7.0
Total	214.8		378.9	

	Saplings			
	Treated unit		Untreated unit	
	# trees/ acre	% compo-	# trees/	% compo-
Douglas-fir (live)	100.6	34.7	134.6	42.4
(dead)	0.7	0.2	4.1	1.3
White fir (live)	146.7	50.6	134.7	42.4
(dead)	10.7	3.7	4.8	1.5
Spruce (live)	8.6	3.0	4.8	1.5
(dead)	0	0	1.4	0.4
Ponderosa pine	22.7	7.8	33.4	10.5
Total	290.0		317.8	

Percent mortality for the host trees (Douglas-fir, white fir, and spruce) was 3.2 and 3.1 for the treated and untreated units, respectively. This is a "natural" mortality figure which cannot be attributed to spruce budworm damage.

Information gathered in the 1977 survey will be used as a base line for data gathered over the next 2 to 3 years. Changes in stocking levels, d.b.h. classes, mortalities, and stand composition will be compared between the treated and untreated areas.

b. Sawtimber

No tree mortality was noted on any of the photo or ground truth plots in either subunit. However, some top-kill was observed.

The number of top-killed Douglas-fir and white fir trees per unit for all 144 plots is given in Table 19. The mean number of top-killed trees per plot in the treatment unit is 1.01 and in the untreated unit is 0.28.

The number of top-killed trees for the 11 ground truth plots was compared with these same 11 photo plots in Table 20. Ground truth plots confirmed the photo scale was satisfactorily close to the desired 1:3300. Regression lines were constructed for the treatment and untreated units, comparing photo plot interpretation against actual ground truth (Table 20). An F-test was used to test the fit of these data to these regression lines. The treated unit showed good agreement between the photo and ground truth plots ($P<0.05$), and the untreated unit showed excellent agreement between the photo and ground truth plots ($P<0.01$). The adjusted top-killed trees for the treatment and untreated units, using the regression estimator, are given in Table 21. Top-killed trees per acre were 4.56 in the treatment unit and 1.51 in the untreated unit.

Table 19.--Number of top-killed Douglas-fir and white fir trees per subunit from all 144 photo interpretation plots[a/], Santa Fe National Forest, 1977.

Treatment Unit		Untreated Unit	
Subunit	No. of top-killed trees	Subunit	No. of top-killed trees
1	1	7	1
2	14	8	2
3	16	9	1
4	9	10	7
5	5	11	3
6	28	12	6
$\bar{x}_1$	1.01		0.28

a/ Half the plots were in the treated unit and half in the untreated units.

Table 20.--Number of top-killed Douglas-fir and white fir trees per plot for ground truth and photo interpretation, Santa Fe National Forest, 1977.

Treatment Unit			Untreated Unit		
Plot #	Ground truth	Photo interpretation	Plot #	Ground truth	Photo interpretation
1	1	1	7	2	1
2	--	--	8	3	1
3	10	3	9	0	1
4	3	3	10	2	2
5	2	3	11	1	1
6	11	7	12	4	3
$\bar{x}_2$		3.40			1.50
$\bar{Y}_2$	5.40			2.00	

Table 21.--Corrected top-killed trees per acre for the treated and untreated units, Santa Fe National Forest, 1977.

	Treatment Unit	Untreated Unit
$\bar{x}1$ - mean a/ tree count on all 72 plots	1.01	0.28
$\bar{x}2$ - mean b/ tree count from ground sample	3.40	1.50
$\bar{Y}2$ - mean b/ tree count from ground truth	5.40	2.00
regression c/ equation $Y = a + b X$	$Y = 1.51 + 0.35 X$ $r = 0.75$	$Y = 0.70 + 0.40 X$ $r = 0.68$
$\bar{Y}Rd$ = adjusted mean tree count $\bar{Y}Rd = \bar{Y}2 + b(\bar{x}1 - \bar{x}2)$	4.56	1.51
Tree per acre	4.56	1.51

a/ From Table 19.
b/ From Table 20.
c/ Fit for regression equations from treatment unit is significant at 5% and for untreated unit at 1%.

V. MONITORING

A. Objectives

The objective of the monitoring phase of the project was to determine if there were any short-term effects of the aerial application of Sevin®-4-oil on birds, aquatic invertebrates, fish, small mammals, reptiles, and certain non-target terrestrial insects.

B. Methods

1. Birds

Monitoring was conducted to describe the short-term response of an avian population to Sevin®-4-oil in a portion of the treatment area. The study area was located along a 1-mile segment of Smokey Bear Hill Road in treatment subunit 3.

The avian population was censused on June 8, 10, 11, and 12, 1977, by one observer to assess pre-treatment densities, and again on June 20 and 21, 1977, to observe the post-treatment population. The post-treatment censuses were done independently by two observers to yield four censuses. Censuses were conducted between 0530 and 0730 hours on a 1-mile long transect using a modified Emlen transect method (Emlen 1971)[6/].

The nests of two insectivorous birds, the violet-green swallow (Tachycineta thalassina) and Williamson's sapsucker (Sphyrapicus thyroideus), were observed for approximately 10 hours before and after insecticide application. The duration of foraging trips was timed to the nearest second and the number of foraging trips per hour to feed nestling was noted.

2. Aquatic Organisms

Three small creeks, San Pablo, Rito la Cueva, and Trail, were monitored to assess the effects of the treatment on aquatic organisms (Fig. 58, A, B, C).

Aquatic monitoring consisted of obtaining six, 10-minute drift samples on each sample day using a 10-inch ring net (Fig. 59). Samples were taken from each creek at 0630, 0700, 0730, 0800, and 1000 and 1400 hours. One substrate sample using a Surber sample was obtained from each creek at 1300 hours on sampling days. The above procedure was followed for pre-treatment, day 0 (treatment), day 7, day 14 (Trail and

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6/ Emlen, J. T. 1971. Population densities of birds derived from transect counts. AuK. 88:323-342.

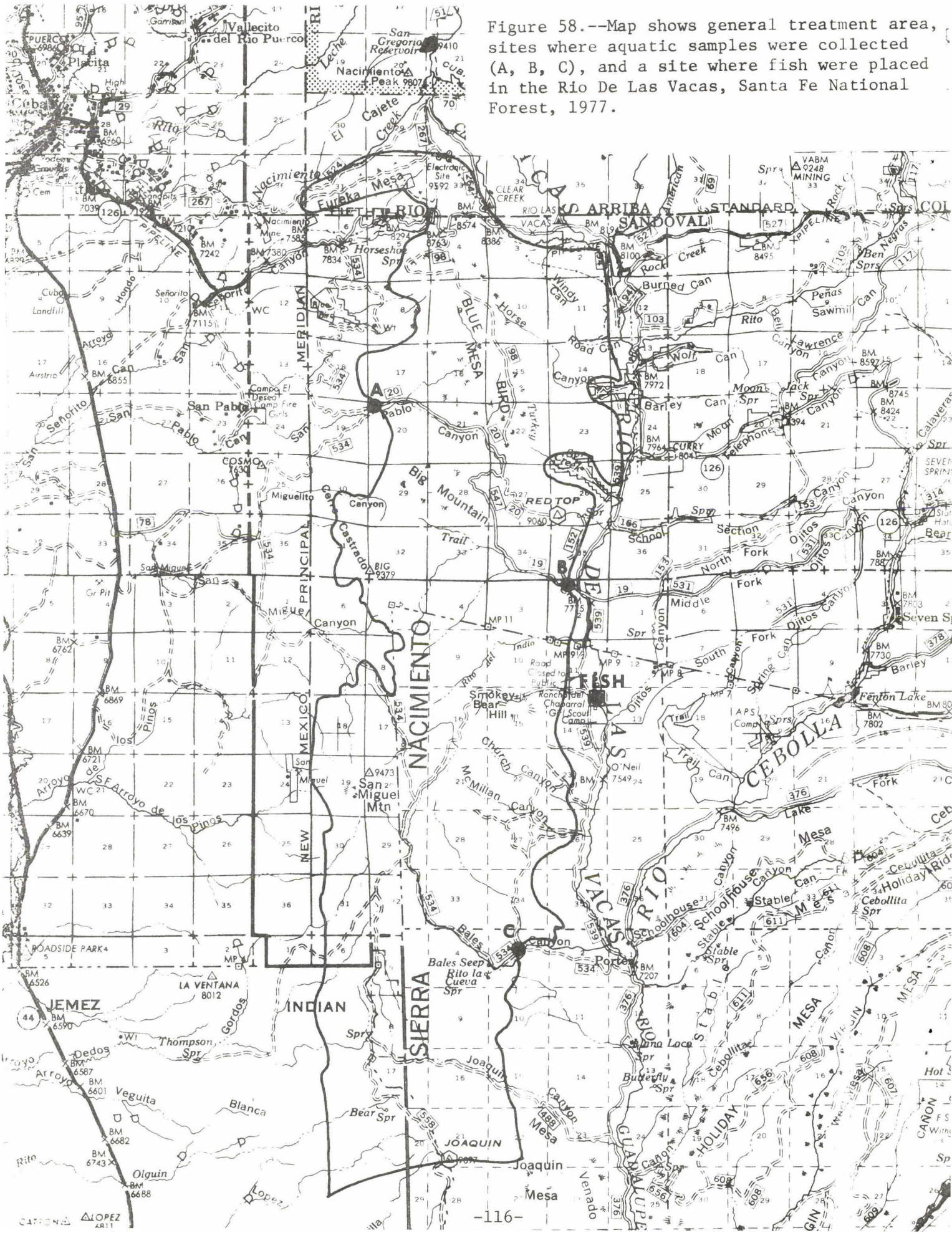
A
B
C
FISH
Vallecito del Rio Puerco
Nacimiento Peak 9807
Nacimiento Mine
Horseshoe Spr
Señorito
San Pablo
Campo El Deseo Camp Fire Girls
COSMO
Miguelito Canyon
Big Mountain Trail
REDTOP
Section School
Burned Can
Barley Can
Moon Spr
Jack Spr Canyon
Lawrence Canyon
Peñas Sawmill Can
Ben Spr
Rock Creek
Windy Can
Road Can
Wolf Can
Bell Canyon
Rito
Horse
Turkey
Ojitos Canyon
North Fork
Middle Fork
South Fork
Seven Spr
Fenton Lake
Barley
Spring Can
Smokey Bear Hill
Ranch del Chaparral Gr Scout Camp
APS Camp
Church Canyon
McMillan Canyon
O'Neil
Schoolhouse Canyon
Stable Spr
Mesa
Cebollita Spr
Holiday
Lake
Bales Canyon
Bales Seep
Rito la Cueva Spr
Porter
Rito Vaca Loca Spr
Butterfly Spr
Joaquin Canyon
Joaquin Mesa
Venado Canyon
Guadalupe Canyon
Holiday Mesa
Canon Spr
Thompson Spr
Bear Spr
Veguita
Blanca
Olguin
Lopez
Arroyo de los Pinos
San Miguel Mtn
Los Pinos
Arroyo Hondo
Arroyo Can
Arroyo de S F Arroyo de los Pinos
Nacimiento Fenton Hill Rd
Jemez Canyon Rd
Cabezon Peak Rd
Cuba Landfill
Gravel Pit
Sandpits
Electronic Site
Gregorio Reservoir
Rio Las Vacas
Rio Arriba Sandoval
Rio Arriba Standard
Rio Arriba Mining
Pipeline
Road Closed to Public
Roadside Park
Mp 11
Mp 9½
Mp 9
Mp 8
Mp 7
Mp 6
Mp 5
Mp 4
Mp 3
Mp 2
Mp 1
Principal Meridian
New Mexico
Nacimiento
Sierra
Jemez
Indian
Joaquin
Cebolla
Rio Las Vacas
Rio Guadalupe
Eureka Mesa
Blue Mesa
Bird Mesa
Cajete Creek
El Rito
Rito Leche
Rito Placita
Rito Cebollita
Rito Gordos
Rito Dedos
Rito Blanca
Rito Olguin
Rito Lopez
Rito Venado
Rito Gin
Rito Hondo
Rito Señorito
Rito Arroyo
Rito Pablo
Rito Miguelito
Rito Castrado
Rito Indio
Rito Del
Rito Cary
Rito Bell
Rito Rock
Rito Negras
Rito Cebollita
Rito Holiday
Rito Vaca Loca
Rito Butterfly
Rito Joaquin
Rito Bales
Rito Porter
Rito Stable
Rito Schoolhouse
Rito Mesa
Rito Virgin
Rito Canon
Rito Gin
Rito Hot
Rito Fenton Lake
Rito Seven Spr
Rito Ojitos
Rito Barley
Rito Moon
Rito Jack
Rito Calaveras
Rito Ben
Rito Peñas

Figure 59.--Harry Kennedy, U. S. Fish and Wildlife Service, collecting aquatic insects, Santa Fe National Forest, 1977.

San Pablo Creeks only), and day 31 (San Pablo Creek only) post-treatment. One, 10-minute drift sample was also obtained for each creek 24 and 48 hours post-treatment. Pre-treatment drift and bottom samples were obtained from Rito la Cueva Creek on June 1, and those from Trail and San Pablo Creeks on June 2.

On June 8, two days prior to the initiation of the spraying, 12 fingerling rainbow trout were placed in each of three minnow traps near the drift sampling sites. A fourth trap, also containing fingerling trout, was placed in the Rio de Las Vacas within the confines of the Rancho del Chaparral Girl Scout Camp (Figure 58, Fish).

A total of 76 samples was collected during the aquatic monitoring study: 32 drift and five Surber samples from San Pablo Creek; 14 drift and two Surbers from Rito la Cueva; and 20 drift and three Surbers from Trail Creek.

3. Small Mammals

Small mammals trap lines were set in two areas. The first area was located in Bales Canyon at an elevation of 2,700 m on Smokey Bear Hill Road (T19N, R1E, Sec. 16) and was to be treated. The area trapped was a fairly steep canyon covered with mixed conifer type and a rich diversity of understory grasses and broad-leaved herbs.

The second area was located in Lake Fork Canyon at an elevation of 2,500 m, 7.2 km NE Porter's Landing (T19N, R2E, Sec. 27). This area was not treated. The topography was similar in both areas. Douglas-fir was dominant.

Trap lines consisting of 100 oatmeal-baited Museum Special snap traps were set in both areas for the pre-spray period. The lines were run for 3 nights and 2 days at each site, June 8-10, 1977, in Bales Canyon, and June 11-13, in Lake Fork Canyon.

Bales Canyon was treated on June 17 and trapped again for 3 nights, June 22-24.

4. Reptiles

A systematic collecting effort was made in Bales Canyon for 8 hours to collect reptiles and amphibians.

5. Non-Target Insects

Attempts to assess the impact of the insecticide on insect populations were made in five ways: (1) Malaise trapping, (2) sweep netting, (3) aerial netting of butterflies, (4) enumeration of blackfly larvae in streams, and (5) black-light trapping.

a. Malaise traps were used to collect airborne insects.

b. Sweep netting was done at both the untreated check and treatment sites for pre- and post-treatment. Eight hundred sweeps were taken at each site.

c. Aerial netting of butterflies was made at three sites in the treatment area before and after spraying.

d. Blackfly larvae were mapped on rocks in Rito la Cueva Creek, Bales Canyon, on June 7, 8, and 12 (pre-treatment). Larval positions were checked during the later two dates to determine if they had moved.

e. Black-light trapping was carried out before spraying for 1 hour (2100-2200 hours) in Bales Canyon, Joaquin Treatment Subunit, and in Lake Fork Canyon, Lake Fork Check Subunit, on 3 nights. For comparison, post-treatment samples were collected 1 night in Bales Canyon and 2 nights in Lake Fork Canyon during the same time frame.

6. Insect Parasites of the Western Spruce Budworm

The parasite complex associated with the western budworm has been identified by Dowden et al. (1948)[7/], Carolin and Coulter (1959)[8/], and McKnight (1967)[9/]. The chalcid, Trichogramma minutum Riley, parasitizes the egg stage of the budworm. The braconid, Apanteles fumiferanae Vier., and the ichneumonid, Glypta fumiferanae (Vier.), parasitize the initial stages of the budworm. Later instars are parasitized by the tachnids, Ceromasia auricaudata Tns., Madremyia saudersii (Will.), and Otoma fumiferanae (Tot.), while the pupae are frequently attacked by ichneumonids, Phaeogenes hariolus (Cress.), Ipoplectus quadricingulata (Prov.), and Ephialtes ontario (Cress.) (McKnight 1971). Additonal parasites have been identified.

A 3-year study was initiated to determine the incidence of insect parasitism in western spruce budworm larval after treatment with Sevin®-4-oil. Budworm larvae and pupae were collected from 20 trees in each of the six treated and six untreated check subunits. Larval and pupal parasites were then reared and identified to determine percent parasitism and which parasites were present.

7/ Dowden, Philip B., W. D. Buchanan, and U. M. Carolin. 1948. Natural control factors affecting the spruce budworm in the Adirondacks during 1946-1948. J. Econ. Entomol. 43:774-783.

8/ Carolin, U. M., and W. K. Coulter. 1959. The occurrence of insects parasites of Choristoneura fumiferana (Clem.), in Oregon. J. Econ. Entomol. 52:550-555.

9/ McKnight, M. E. 1967. Ecology of the Western Budworm, Choristneura occidentalis Freeman, (Lepidoptera:Tortricidae) in Colorado. PhD Dissertation. Colorado State University 206 p. University Microfilms, Ann Arbor, Michigan.

C. Results

1. Birds

A total of 40 avian species was observed in the study area. Twenty-five species were breeding in the area and the remaining 15 were capable of reproducing in this habitat (Bailey 1928; Hubbard 1965; Tatschl 1967). There was no significant change in adult population densities or diversity in the treatment area during the study period. Therefore, pre- and post-treatment censuses were combined in estimating breeding bird densities (Table 22). The total breeding bird density was 171.0 pairs/40 hectares. This estimate is probably conservative because some species, especially those that had finished breeding by the time the study began could not be accurately censused. Field observations gave no indication of acute toxicity or other immediate effects on nestling birds. No deformities, suggesting carbaryl acted as a teratogen, were noted.

Adult foraging rates and the rates nestlings are fed can be used as an index of resource density and, hence, habitat quality (Carothers 1974; Gibb 1956; Verbeek 1964; Verner 1965). Thus, if the insecticide killed a significant number of insects, the rates at which nestlings are fed could be expected to decrease because the parents would expend more time searching for food. No significant difference in the pre- and post-treatment feeding rates of the two species studied (the violet-green swallow and Williamson's sapsucker) was found during the study period. No evidence of starvation or malnutrition among nestlings, which would have indicated the possibility of a decline in food resource quality and/or quantity, was seen.

2. Aquatic Organisms

a. San Pablo Creek

Subunit 5 (Blue Bird) was treated on June 11. This subunit contained San Pablo Creek, a small, but permanent creek in San Pablo Canyon. The creek and sampling site are identified in Figure 58.

Aerial spraying near the San Pablo sampling site began about 0600 hours and was completed by 0630. Flow of the creek was estimated to be about 0.2 cubic feet per second (ft^3/s). Water temperature ranged from 44° F at 0630 to 57° F at 1400 hours. Air temperature ranged from 44° F at 0630 to 75° F at 1400 hours. Wind velocity was minimal and sky was clear.

At approximately 0600 hours, the creek was accidentally oversprayed (see Section II. E. 9.).

Table 22.--Breeding birds on Smokey Bear Hill Road study site, Subunit 3, Santa Fe National Forest, June 1977.

Species		Pairs per 40 hectares
Turkey Vulture	*Cathartes aura*	-
Cooper's Hawk	*Accipiter cooperii*	-
Red-tailed Hawk	*Buteo jamaicensis*	-
Turkey	*Meleagris gallopavo*	-
Mourning Dove	*Zenaida macroura*	-
Great-horned Owl	*Bubo virginianus*	-
Pygmy Owl	*Glaucidium gnoma*	-
Lesser Nighthawk	*Chordeiles acutipennis*	-
Rufous Hummingbird	*Selasphorus rufus*	-
Broad-tailed Hummingbird	*Selasphorus platycercus*	3.3
Red-shafted Flicker	*Colaptes auratus*	3.7
Williamson's Sapsucker	*Sphyrapicus thyroideus*	4.7
Hairy Woodpecker	*Dendrocopus villosus*	1.5
Northern Three-toed Woodpecker	*Picoides tridactylus*	-
Empidonax species	*Empidonax* sp.	2.8
Western Wood Pewee	*Contopus sordidulus*	6.1
Violet-green Swallow	*Tachycineta thalassina*	-
Steller's Jay	*Cyanocitta stelleri*	2.8
Common Raven	*Corvus corax*	0.5
Clark's Nutcracker	*Nucifraga columbiana*	3.3
Mountain Chickadee	*Parus gambeli*	7.9
White-breasted Nuthatch	*Sitta carolinensis*	0.5
Red-breasted Nuthatch	*Sitta canadensis*	3.3

Table 22.--continued.

Species		Pairs per 40 hectares
Pygmy Nuthatch	*Sitta pygmaea*	-
House Wren	*Troglodytes aedon*	23.3
American Robin	*Turdus migratorius*	11.2
Hermit Thrush	*Catharus guttata*	8.4
Western Bluebird	*Sialia mexicana*	0.9
Townsend's Solitaire	*Myadestes townsendi*	1.4
Golden-crowned Kinglet	*Regulus satrapa*	1.4
Ruby-crowned Kinglet	*Regulus calendula*	18.2
Warbling Vireo	*Vireo gilvus*	42.0
Orange-crowned Warbler	*Vermivora celata*	-
Audubon's Warbler	*Dendroica coronata*	10.7
Western Tanager	*Piranga ludoviciana*	0.5
Black-headed Grosbeak	*Pheucticus melanocephalus*	-
Evening Grosbeak	*Hesperiphona vespertina*	0.9
Pine Siskin	*Spinus pinus*	-
Gray-headed Junco	*Junco hyemalis*	8.9
Chipping Sparrow	*Spizella passerina*	2.8

The first 10-minute drift sample was obtained at 0630. There was a slight increase in drift organisms as compared to the same time period for the pre-treatment sample (Table 23). The overspray first affected the more sensitive members of the mayfly family Baetidae. The full impact of the Sevin®-4-oil spray application was evident between 0700 and 0800, 1½ hours after the overspray occurred (Fig. 60). The most seriously affected insects were mayflies of the families Baetidae and Heptageniidae, Plecoptera nymphs of the families Chloroperlidae and Nemouridae, Trichoptera larvae of the families Lepidostomatidae and Limnephilidae, Coleoptera larvae of the family Elmidae, and Diptera larvae of the family Simulidae. Drift samples taken at 24 and 48 hours, and 7, 14, and 31 days, post-treatment gave little evidence of recovery for any of these insect families, except for Simulidae, and early instar larvae of the caddisfly family Limnephilidae.

There was a decline in numbers and kinds of organisms collected from Surber samples after treatment day: pre-treatment, 147; treatment, 215; day 7, 27; day 14, 90; day 31, 29 (Table 23). The high number (215) recorded from the sample on treatment day may have been caused by placing the Surber sampler over an area that contained insects that died earlier in the morning. Elmidae larvae appeared to show the best recovery from day 7 through day 31 post-treatment. Turbellaria (Planaria) was the most tolerant organism, as they were active even during the critical period between 0700 and 0800 hours.

The rainbow trout fingerlings placed in the minnow trap at the sampling site showed no signs of distress or symptoms of acute toxicity to the Sevin®-4-oil application. All fish were released in the creek at day 7 post-treatment.

b. Rito la Cueva Creek

Subunit 2 (Joaquin) was treated on June 12. This plot contained Rito la Cueva Creek, another small, but permanent creek with a much larger drainage area than either San Pablo or Trail Creek. Rito la Cueva Creek normally empties into the Rio de Las Vacas, but during this study the creek was dry at its lower reaches. The creek and sampling site are identified in Figure 58.

On treatment day, flow at the sample site was estimated to be about 0.5 ft^3/s. Water temperature ranged from 48° F at 0630 to 64° F at 1400. Air temperature at 0630 was 42° F and at 1400 had risen to 83° F with clear skies and minimal winds.

The initial 10-minute drift sample was obtained at 0630 hours. There was no significant impact to aquatic fauna as a result of the aerial application of the insecticide (Table 24). The difference in numbers of organisms represented, mostly blackfly larvae,

Table 23.--Aquatic invertebrate analyses of drift and Surber samples at pre-treatment, treatment, and post-treatment days from the application of Sevin®-4-oil to the San Pablo Creek drainage, Santa Fe National Forest, June, 1977.

	PRE-TREATMENT JUNE 2							TREATMENT JUNE 11							POST-TREATMENT 10 MINUTE DRIFT								POST-TREATMENT 10 MINUTE DRIFT								POST-TREATMENT 10 MINUTE DRIFT							
	10 MINUTE DRIFT						Surber	10 MINUTE DRIFT						Surber	24-Hour	48-Hour	Day 7						Surber	Day 14						Surber	Day 31						Surber
ORGANISM	0630	0700	0730	0800	1000	1400	1300	0630	0700	0730	0800	1000	1400	1300	0800	0800	0630	0700	0730	0800	1000	1400	1300	0630	0700	0730	0800	1000	1400	1300	0630	0700	0730	0800	1000	1400	1300
EPHEMEROPTERA																																						
Baetidae	2	2	--	2	5	1	--	24	457	274	81	13	13	25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Heptageniidae	--	--	--	--	--	--	--	1	4	96	14	2	1	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Siphlonuridae	--	--	--	--	--	--	--	--	--	2	2	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PLECOPTERA																																						
Chloroperilidae	--	1	--	2	2	--	2	1	300	67	17	6	8	7	4	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nemouridae	--	--	--	--	--	--	35	--	14	1438	1310	46	45	56	9	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perlidae	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perlodidae	--	--	--	--	--	1	--	--	16	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HEMIPTERA																																						
Gerridae	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--
Veliidae	--	--	2	1	--	--	--	--	7	--	--	2	4	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	2	--	--	--	1	--	--	--	--	--
TRICHOPTERA																																						
Glossosomatidae	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--
Lepidostomatidae	--	2	1	--	4	--	6	--	27	68	30	8	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--
Lemnephilidae	2	1	--	--	1	1	2	1	4	31	19	8	12	1	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2*	--	--	2*	2*	2*	--
COLEOPTERA																																						
Dytiscidae	--	--	--	--	--	--	--	--	2	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
Elmidae	--	--	--	--	--	1	61	7	4	4	2	4	3	48	--	--	--	--	--	1	2	1	9	--	1	1	--	1	1	51	--	1	--	2	1	--	9
DIPTERA																																						
Chironomidae	1	1	--	--	--	--	10	--	--	4	9	9	10	52	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dixidae	--	--	--	--	--	--	1	1	6	8	7	2	2	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Simulidae	1	1	2	2	--	--	--	1	117	16	6	16	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Stratiomyidae	--	--	--	--	--	1	10	2	--	--	--	2	2	7	2	1	--	--	--	--	--	--	5	--	3	1	--	1	--	28	2	2	2	--	3	8	--
Tipulidae	--	--	--	--	--	--	5	1	31	104	90	32	26	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
COLLEMBOLA	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ACARI	--	--	--	--	--	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	2	--	--	--	--	1	--	--
HIRUDINEA	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TURBELLARIA	--	--	--	1	--	--	10	6	15	2	2	3	3	10	1	1	2	1	5	--	3	--	6	22	1	2	--	--	--	4	--	--	2	4	1	--	19
TERRESTRIAL	--	--	--	1	1	--	5	2	2	1	4	6	6	--	--	2	--	--	--	--	1	5	--	1	--	1	--	3	2	2	--	1	1	1	2	2	--
UNIDENTIFIED	--	--	--	--	--	--	--	--	--	--	4	--	3	--	--	1	1	--	--	--	1	--	1	1	--	--	1	1	1	1	--	--	--	--	--	1	--
TOTALS	6	8	5	10	13	6	147	47	1007	2122	1597	161	157	215	21	8	5	1	5	1	8	6	27	24	5	5	1	6	6	90	4	4	6	9	11	13	29
AVERAGE	8						147	849						215	21	8	4						27	8						90	8						29

* Early instars.

Figure 60.--Aquatic drift samples collected in San Pablo Creek on Treatment day, June 11, 1977, Santa Fe National Forest.

Table 24.--Aquatic invertebrate analyses of drift and Surber samples at pre-treatment, treatment, and post-treatment days from the application of Sevin®-4-oil to the Rito la Cueva Creek drainage, Santa Fe National Forest, June, 1977.

	PRE-TREATMENT JUNE 1							TREATMENT JUNE 12							POST-TREATMENT	
	10 Minute Drift						Surber	10 Minute Drift						Surber	24-Hour	48-Hour
ORGANISMS	6:30	7:00	7:30	8:00	10:00	2:00	1:00	6:30	7:00	7:30	8:00	10:00	2:00	1:00	8:00	8:00
EPHEMEROPTERA																
Siphlonuridae	--	1	--	3	1	1	--	--	--	--	1	--	1	1	--	--
PLECOPTERA																
Chloroperlidae	--	--	--	--	--	--	--	--	--	--	--	1	--	2	--	--
TRICHOPTERA																
Limnelphilidae	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--
COLEOPTERA																
Dytiscidae	--	--	--	--	4	3	--	1	--	1	1	6	4	2	1	--
Elmidae	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--
DIPTERA																
Blepharoceridae	--	--	--	--	--	--	13	--	--	--	--	--	--	--	--	--
Chironomidae	--	--	9	--	1	--	3	--	--	--	--	1	--	2	3	1
Dixidae	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--
Simulidae	--	--	5	2	1	--	285	1	4	10	3	1	2	78	--	9
ACARI	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--
TERRISTRIAL	--	--	--	1	--	1	--	--	--	--	--	--	2	1	--	--
UNIDENTIFIED	1	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--
TOTALS	1	1	14	8	8	6	301	2	5	11	5	9	10	86	4	10
AVERAGE	6						301	7						86	4	10

between the Surber samples taken at pre-treatment (285) and treatment day (78) can be explained in that the habitat of Rito la Cueva Creek contained a more diversified substrate; the different substrates sampled (several small rocks for pre-treatment, large rocks on treatment) on each of these 2 days accounts for the discrepancies in the number and kinds of organisms collected. Because we observed no adverse effects to the aquatic insect fauna were observed through the 48-hour post-treatment sample, no additional monitoring was done.

The rainbow trout fingerlings placed in a minnow trap near the sampling site remained active throughout the exposure period. No mortality occurred and all fish were released in the creek after the 48-hour post-treatment sample was taken.

c. Trail Creek

Subunit 4 (Trail) was treated over a period of 2 days. The lower areas where the sampling station was located were treated on June 15, and the upper drainage on June 16. This subunit contained Trail Creek, another small, but permanent creek and the only creek that flowed into the Rio de Las Vacas. The creek and sampling site (B) are identified in Figure 58.

The aerial application over the lower end of this subunit began at daybreak and was completed by midmorning. On treatment day, flow at the sample site was estimated to be about 0.2 ft^3/s. Water temperature ranged from 47° F at 0630 to 66° F at 1400 hours. Air temperature ranged from 48° F at 0630 to 77° F at 1400 hours. Sky was clear and wind was minimal.

The initial 10-minute drift sample was taken at 0630 hours. As noted in Table 25, it is difficult to say whether or not there was any significant increase in the numbers and kinds of insects recorded between the six sample periods for pre-treatment and treatment day.

There was a decline in numbers and kinds of organisms collected from Surber samples (Table 25): pre-treatment, 184; treatment, 22; and day 7, 92. Almost all major groups of insects were affected. The groups most affected were mayflies, caddisflies, aquatic Coleoptera, and dipterans of the family Chironomidae. By day 7 post-treatment, the mayflies had shown very little recovery; caddisflies of the family Glossosomatidae and the coleopteran Elmidae were beginning to show signs of recovery.

Although no aquatic samples were collected from the upper reaches of Trail Creek that was treated on June 16, there was visual evidence that spray reached the stream (Fig. 61). It seems rather apparent

Table 25.--Aquatic invertebrate analyses of drift and Surber samples at pre-treatment, treatment, and post-treatment days from the application of Sevin®-4-oil to the Trail Creek drainage, Santa Fe National Forest, June, 1977.

	PRE-TREATMENT JUNE 2							TREATMENT JUNE 15							POST-TREATMENT 10 MINUTE DRIFT								
	10 MINUTE DRIFT						Surber	10 MINUTE DRIFT						Surber	24-Hour	48-Hour	Day 7						Surber
ORGANISM	6:30	7:00	7:30	8:00	10:00	2:00	1:00	6:30	7:00	7:30	8:00	10:00	2:00	1:00	8:00	8:00	6:30	7:00	7:30	8:00	10:00	2:00	1:00
EPHEMEROPTERA																							
Baetidae	3	3	--	1	2	1	17	3	2	1	2	--	4	--	--	--	--	--	--	--	--	--	3
Heptageniidae	1	--	--	--	--	--	18	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--
Leptophlebidae	1	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Siphlonuridae	--	--	--	--	--	1	2	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tricorythidae	--	--	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PLECOPTERA																							
Nemouridae	2	--	--	--	--	--	6	--	1	--	--	--	16	11	--	--	1	---	--	--	--	--	--
HEMIPTERA																							
Nacouridae	--	--	--	--	--	--	1	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	1
Veliidae	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	3
TRICHOPTERA																							
Glossosomatidae	--	--	--	--	--	--	33	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	16
Hydropsychidae	--	--	--	--	--	--	11	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--
Lepidostomatidae	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Limnephilidae	1	--	--	--	--	--	1	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
Rhyacophilidae	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
COLEOPTERA																							
Elmidae	6	--	1	--	2	--	76	--	2	--	--	--	--	5	1	--	--	--	2	--	--	--	59
DIPTERA																							
Chironomidae	--	--	--	--	--	--	12	--	--	--	--	1	1	1	--	--	1	--	--	--	--	--	1
Tipulidae	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
Simulidae	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
COLLEMBOLA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	1
HIRUDINEA	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
TURBELLARIA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
TERRISTRIAL	1	--	--	--	--	--	--	--	--	--	1	--	1	--	1	1	1	--	--	--	1	--	2
UNIDENTIFIED	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1	--	2
TOTALS	15	3	1	1	5	2	184	4	6	1	3	2	25	22	3	1	3	0	3	0	2	0	92
AVERAGE				5			184				7			22	3	1			1				92

Figure 61.--Aquatic insects killed by treatment in Upper Trail Creek, Santa Fe National Forest, 1977.

that the data presented in Table 25 for drift and Surber samples at 24 and 48 hours and day 7 post-treatment is not indicative of the spray application to the lower end of Trail Creek on June 15. The delayed mortality of the insect fauna must have been caused by spray drift in the middle and upper areas of Trail Creek on June 16.

Because our visual observations of the samples collected, and observations of the creek itself, did not clearly indicate that the insecticide was adversely affecting the aquatic fauna, we did not continue the monitoring past day 7. The analytical data indicates that an effect did occur and monitoring should have continued to determine the long range effects of the insecticide.

The rainbow trout fingerlings placed in a minnow trap at the sampling site remained active throughout the exposure period. There were no losses and fish were released in the creek after the day 7 post-treatment sample was completed.

3. Reptiles

Although three species of reptiles (fence lizard (Sceloporus undulatus), horned lizard (Phrynosoma douglassi), garter snake (Thamnophis elegans)) have been taken in Bales Canyon (the sprayed area), 8 hours of systematic collecting effort produced nothing in the way of reptiles and amphibians.

Densities this low could not be meaningfully studied with respect to the effects of insecticide treatment.

4. Mammals

The results of the trapping effort are given in Table 26. Thirteen animals were taken in Bales Canyon during the pre-spray period and 12 in the post-spray period. These methods detected no immediate effects of the insecticide on small mammal populations.

5. Non-Target Insects

Results by assessment method follow.

a. Malaise Traps

Overall, trapping results were not significantly different before and after treatment.

Table 26.--Results of small mammal trapping (number of animals trapped) in the spray area (Smokey Bear Hill Road, Subunit 3) and untreated check area (4.5 mi NE Porter's Landing, Lake Fork Canyon, Subunit 8). Each date is 100 trap nights.

	PRE-SPRAY PERIOD						POST-SPRAY PERIOD		
	Spray Area			Control Area			Spray Area		
	8 June	9 June	10 June	11 June	12 June	13 June	22 June	23 June	24 June
Peromyscus maniculatus	4	3	3	5	0	2	3	3	0
Eutamias minimus	2	0	1	0	2	0	6	0	0
Total animals			13			9			12

b. Sweep Netting

The results of the sweep netting were not analyzed in detail because variability in the sweeping condition appeared to mask any other effects. No conclusions were made in terms of taxa composition or abundance.

c. Aerial Netting Butterflies

There was no short-term spray effects on adult butterfly population density in the treated area.

d. Blackfly Larval Mapping

The location of larvae on rocks was mapped on June 7 in Rito la Cueva Creek. They were in the same positions on June 8. On June 12, before the spray date, all larvae had disapperared from the rocks and no effects of treatment were obtained.

e. Black-Light Trapping

The results of the black-light trapping are summarized in Table 27. Insect biomass, number of species, and number of insects per species did not appear to be affected by the treatment.

6. Insect Parasites of the Western Spruce Budworm

Even though all parasites collected have not been identified, as yet, it appears that the parasite complex is similar to that found in Colorado by McKnight (1967). However, several new ichneumonid species were collected.

Preliminary results indicate that the rate of parasitism for late-instar larvae and early pupae of budworms in the treated and untreated check subunits were virtually identical. Data for early-instar larvae and late pupae have not been summarized.

More detailed results of the first year parasite studies will be included in Progress Report 2.

Table 27.--Number of individuals and biomass (gm) taken in light traps in Bales Canyon, treatment subunit 2, and Lake Fork Canyon, untreated check subunit 8. Each night the trap was activated at 2100 and closed at 2200 hours.

	SPRAY AREA					CONTROL AREA				
	Pre-Spray Period			Post-Spray Period		Pre-Spray Period			Post-Spray Period	
	7 June	8 June	9 June	22 June	23 June	10 June	11 June	12 June	21 June	
LEPIDOPTERA										
Biomass (gm)	2.00	0.93	1.17	1.66	0.76	1.33	2.60	0.65	2.86	
Saturniidae (No.)	12	11	10	15	9	23	19	12	34	
Individuals	21	18	17	37	17	56	34	18	89	
HYMENOPTERA										
Biomass (gm)	0.01	0.02	0.01	<0.01	0	0	0	0	0	
Individuals	1	2	1	1	0	0	0	0	0	
DIPTERA										
Biomass (gm)	0	<0.01	<0.01	<0.01	0.01	0.02	0.01	0.01	<0.01	
Individuals	0	5	3	3	1	40	10	5	24	
COLEOPTERA										
Biomass (gm)	0	0.10	0	0	0	0	0	0	0	
Individuals	0	2	0	0	0	1	0	0	0	
HOMOPTERA										
Biomass (gm)	0	0	0	0	0	<0.01	0	0	0	
Individuals	0	0	0	0	0	1	0	0	0	

VI. PLANS FOR F.Y. 1979

Evaluation of the effectiveness of chemical treatment for the budworm generation N+1 is planned for F.Y. 1978. Entomological sampling methods described in Sections III. 4. a. will be used with the exception of sampling of bud-mining larvae. Tree damage assessment (Section IV. B.) and environmental monitoring (Section V. B.) also are planned for 1978.

The total costs for the second year of the program was expected to cost $44,467. However, an updated financial plan, using Albuquerque as the duty station of seasonal employees and a field camp headquarters, shows that the costs will be higher than expected. A F.Y. 1978 financial plan follows:

		1978 budget	FIDM	Total
A.	Equipment Rental			
1.	5, GSA, ½-ton pickups, 4-speed, 4X2, 6-cylinder, with 2,000 miles of use per month for 3.5 months at $60.00 per month and .08¢ per mile	$ 3,050	$ 0	$ 1,850
2.	1, GSA, ½-ton pickup, 4-speed, 4X2, 6-cylinder, 2,000 miles per month for 3.5 months	900	0	900
3.	1, GSA van, 2,000 miles per month for 1 month	300	0	300
	Subtotals	$ 3,050	$ 0	$ 3,050
B.	Equipment and Supply Purchases			
1.	Field sampling and laboratory equipment (tree paint, alcohol preservative; map copying; printing, etc.)	$ 1,000	$ 0	$ 1,000
2.	Laboratory facility (compressor for second walk-in cooler; modify TM inventory room for cooling; paint)	0	1,000	1,000

		1978 budget	FIDM	Total
3.	Camp equipment and supplies (repair tents, tables, stoves, cooking gear, ice chests, etc.)	$ 1,000	$ 600	$ 1,600
4.	Seligman Girl Scout Camp leasing for 3.5 months	2,000	0	2,000
	Subtotals	$ 4,000	$1,600	$ 5,600
C.	Personnel			
1.	2 subunit leaders, GS-404-5 (85 days @ $38.32 per day) (temporary position for project)	$ 6,500	$ 0	$ 6,500
2.	6 crew members, GS-404-4 (85 days @ $34.24 per day per crew member) (temporary positions with project)	17,500	0	17,500
3.	2 crew members, GS-404-4 (50 days @ $34.24 per day per crew member) (temporary positions with FIDM)	0	3,400	3,400
4.	Mike, laboratory leader, GS-404-5 (85 days @ $42.16 per day)	0	3,600	3,600
5.	Bob, project entomologist GS-414-11 (85 days @ $79.60 per day)	0	3,800	3,800
	Subtotals	$24,000	$10,800	$34,800
D.	Administrative			
1.	Per diem for 8 project temporaries ($10/day, camp rate for 85 days)	$ 6,800	$ 0	$ 6,800

		1978 budget	FIDM	Total
2.	Per diem for 2 FIDM temporaries ($10/day, camp rate for 50 days)	$ 1,000	$ 0	$ 1,000
3.	Per diem for 2 FIDM permanents (Mike & Bob, $10/day, camp rate for 85 days)	1,700	0	1,700
4.	Overtime for pre-spray sampling (10-hour days for 10 straight days, including 2 weekends, for 12 people)	4,600	0	4,600
	Subtotals	$14,100	$ 0	$14,100
E.	Service			
1.	Data analysis	$ 500	$ 0	$ 500
2.	Overhead (R-3 @ 5% in F.Y. 1978)	2,300	0	2,300
	Subtotals	$ 2,800	$ 0	$ 2,800
	Grand Totals	$47,950	$12,400	$60,350

A progress report summarizing the results of the 1978 sampling will be issued in early 1979.